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### 3. Idaho Chemical Processing Plant (ICPP)

ICPP is operated by Allied Chemical Company (ACC) for ERDA. The primary purpose of the plant is to recover enriched uranium from spent fuel. Figure II-15 is an aerial view of ICPP.

To recover the uranium, ICPP processes highly enriched irradiated nuclear reactor fuel elements consisting of uranium clad in aluminum, zirconium, or stainless steel alloys; provisions are being made for future processing of graphite based fuels. Waste materials separated from the recovered uranium that are high in radiation are contained within the facility; those below the discharge limits (ERDAM-0524) are released under controlled and monitored conditions.

Fuels of U.S. origin and manufacturing are shipped to ICPP from test and research reactors at INEL, from other research reactors (including some in foreign countries), and from the U. S. Navy's ship propulsion reactors (environmental assessments for transporting irradiated fuel have been published in WASH-1238 and WASH-1237). Fuels from some commercial power demonstration reactors are also being stored at ICPP pending disposition. Altogether, fuels from about 40 reactors are stored or scheduled to be processed in the near future at ICPP. Facility design for processing Rover and High Temperature Gas Reactor (HTGR) fuels have been completed, and separate environmental statements have been prepared and issued as WASH-1512 and WASH-1534, respectively. WASH-1512 describes the impact from the receipt, storage, and processing of Rover fuel from the AEC/NASA joint nuclear rocket project at the Nuclear Rocket Development Station in Nevada. WASH-1534 describes the impact from the receipt, storage, and processing of fuel from the Ft. St. Vrain Reactor, a HTGR near Platteville, Colorado.

Irradiated fuel shipped to ICPP is received in heavily shielded casks, then transferred to the Fuel Storage Facility and stored to await processing. The processing methods at ICPP begin with dissolution of the fuel in acid. The resulting solution contains a nitrate solution of uranium (uranyl nitrate), fission product nitrates, and small quantities of transuranics. This solution is mixed with an organic solvent in which the uranium is preferentially soluble. The uranium goes into the solvent (a process called "extraction"), thus separating it from the radioactive fission products. To purify the uranium further, it is removed from the solvent by a dilute acid solution; the process is repeated two more times to obtain highly purified uranium in a uranyl nitrate solution. The last acid extraction produces a uranyl nitrate solution from which practically all fission products and other impurities have been removed. This product is pure enough that it can be shipped without shielding for radioactivity. Normally, the solution is converted to a solid uranium oxide powder by a denitration process at ICPP prior to shipping. The uranyl nitrate solution or the uranium oxide powder is shipped to either Oak Ridge National Laboratory (ORNL) or to Goodyear Atomic Company, Portsmouth, Ohio, for further processing to obtain uranium that can be remanufactured into fuel elements. A perspective view of the ICPP area is shown in Figure II-16. A schematic flowsheet of the fuel reprocessing sequences is shown in Figure II-17.

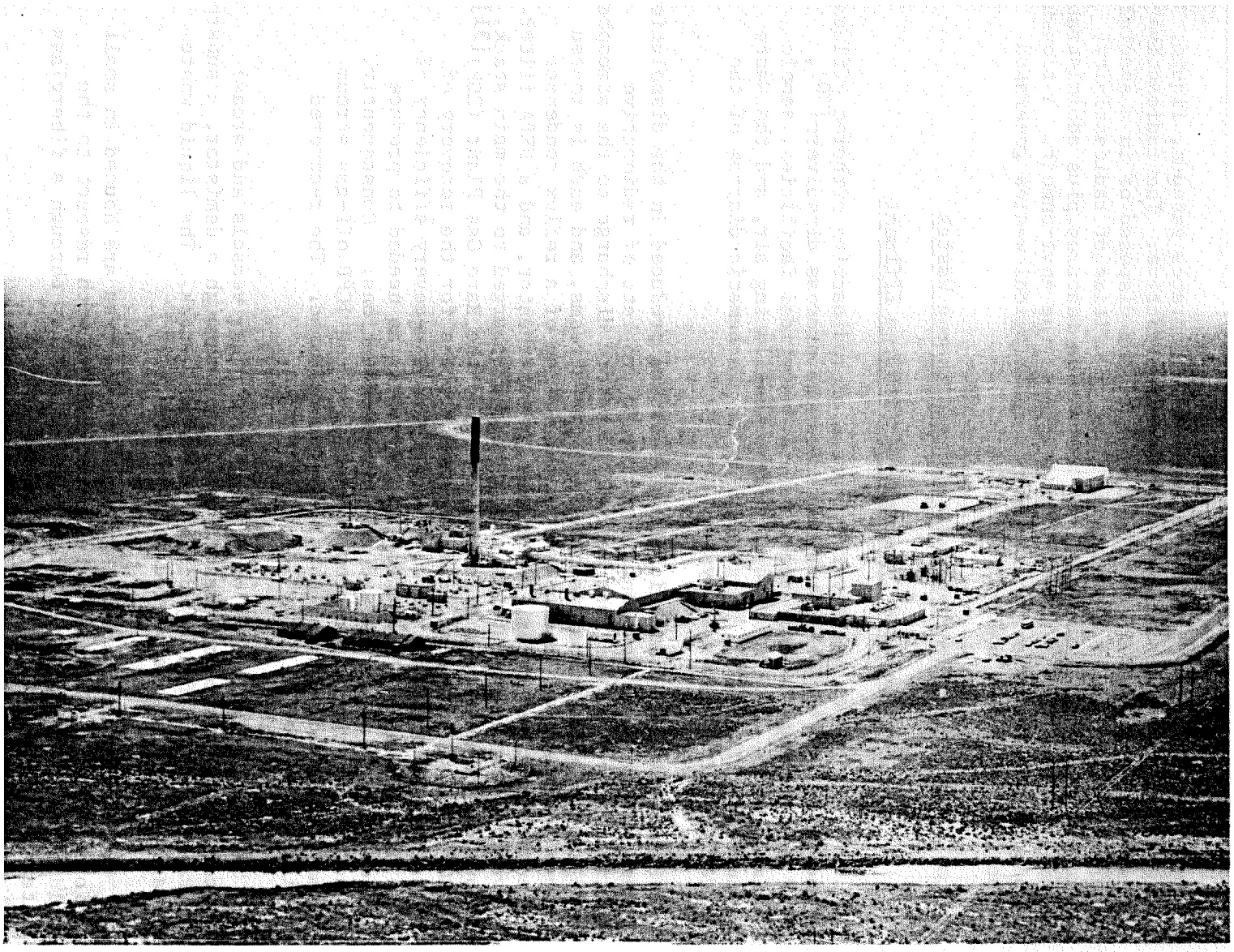

Figure II-15. Aerial View of ICPP.

The reprocessing of spent nuclear fuel generates gaseous, liquid, and solid wastes, both radioactive and nonradioactive. The radioactive wastes must be processed further or handled and disposed of in a special manner to prevent release of unacceptable quantities of radioactivity to the environment. Various safety and design features plus administrative controls are used to ensure minimal impact to the environment. A flowsheet of calculated quantities of activity in radiological wastes generated at the ICPP is shown in Figure II-18.*

a. System for Venting Radioactive Airborne Wastes

(1) Sources and Treatment of Airborne Effluent

There are several sources of radioactive airborne effluent at the ICPP. The major contributors are the process dissolvers[30], other process vessels and areas, remote analytical facilities, sample stations, waste solvent burner, process ventilating air, and the Waste Calciner Facility (WCF). Figure II-19 is a schematic diagram of the entire ICPP airborne waste system.

Radioactive and nonradioactive gases are produced in the dissolution process. These gases may contain entrained droplets of radioactive solutions; the droplets must be removed before discharge to the atmosphere. There are three separate dissolver off-gas streams, and each is routed through an extensive cleanup system consisting of a reflux condenser and entrainment separator, a demister, a superheater, and a HEPA filter. The various dissolver off-gas streams are discharged to the main stack. All but one of the streams can be routed to the Rare Gas Plant (RGP)[31]. The RGP houses a cryogenic distillation process for the recovery of radioactive krypton and xenon. The RGP has a recovery efficiency of 25 to 45% and is only operated intermittently as needed to produce krypton-85 for industrial and research applications. Consequently, the actual quantity of krypton removed from the ICPP off-gas stream is small compared with the total krypton released. The recovered gas is shipped to Oak Ridge for distribution.

The remaining process off-gases (from other vessels and areas) are collected in a common header and routed through a demister, a superheater, a HEPA filter, and finally discharged to the stack. The liquid waste storage tanks also are vented to this stream.

Process sampling stations throughout the area are housed in small cubicles which are kept at a negative pressure with respect to the building ventilating air. These cubicles exhaust through a fiberglass filter to the stack.

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*For discussion of a possible major expansion at the ICPP involving a new headend processing system ("Fluorinel") and new fuel handling and storage capability, see Appendix E.7.a.

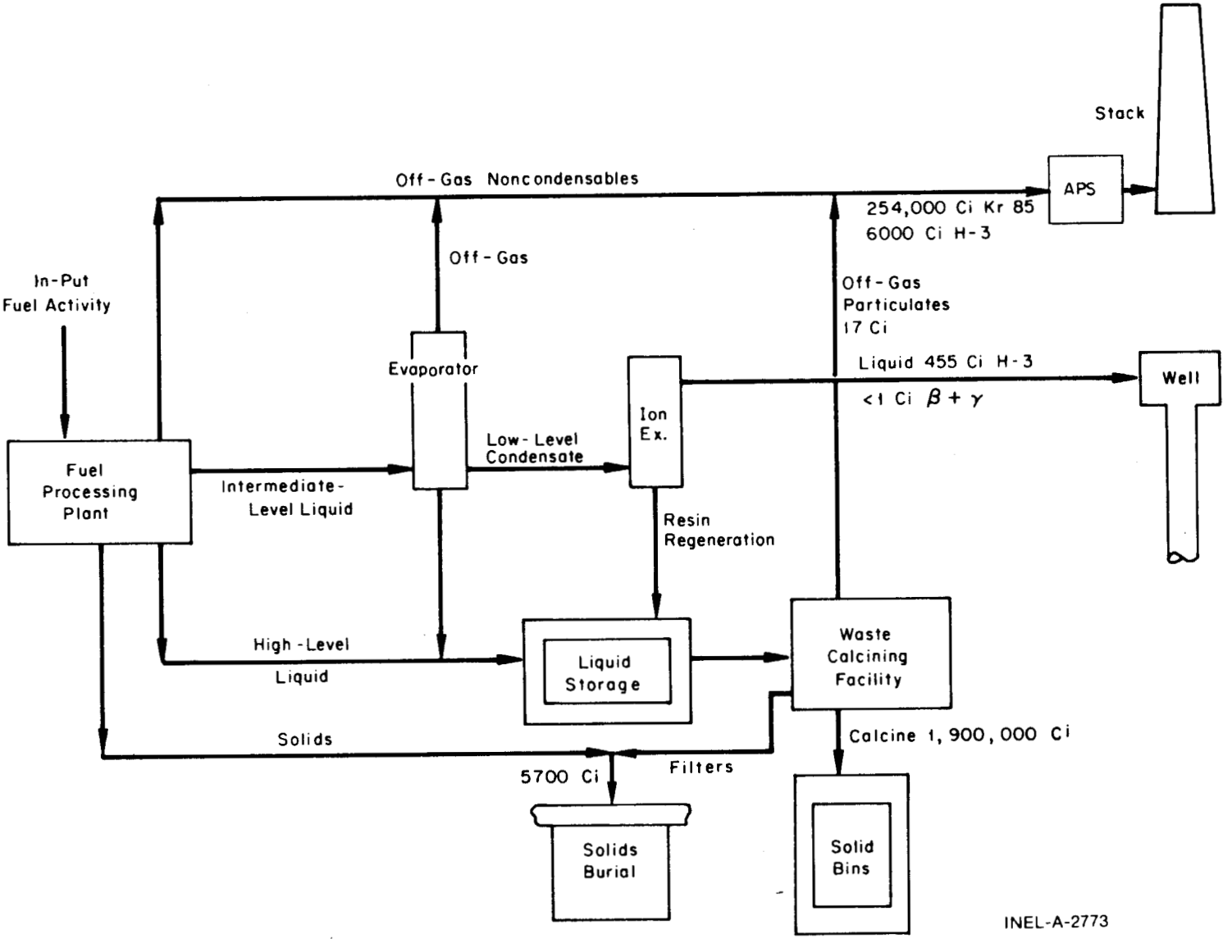


Figure II-18. ICPP Radioactive Waste System Flowsheet and Activity Levels for 1974.

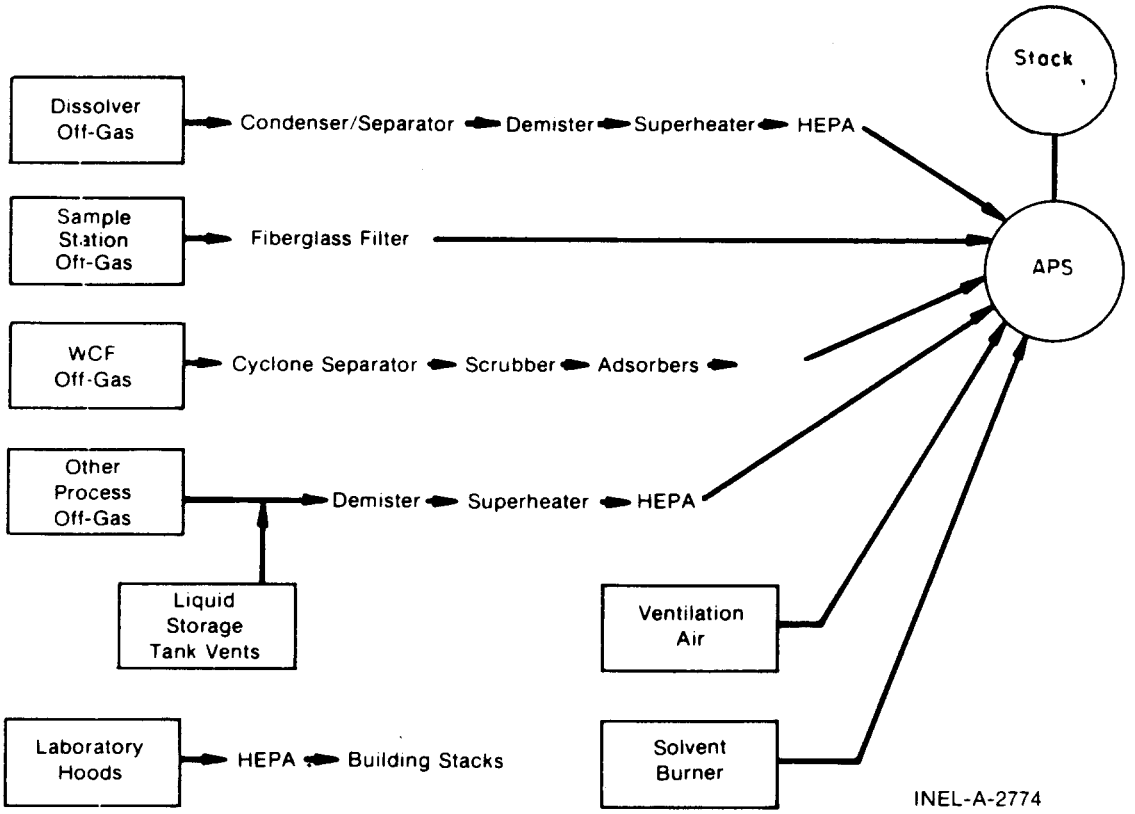


Figure II-19. ICPP Airborne Waste System.

Low-level contaminated solvent from the solvent extraction process is steam distilled to remove most of the contamination, then burned in a solvent burner; the resulting waste gases are routed directly to the stack. A comparison of the average calculated concentrations resulting from the solvent burner operation with the reported release values for the ICPP stack are shown for strontium-90, ruthenium-106, and plutonium in Table II-16. A contribution ratio (solvent waste burner emissions to total ICPP plant emissions) is also indicated. The radioactivity released from the solvent waste burner is monitored at the stack and included in the total release values presented in Tables II-17 and II-18.

Ventilating air from the processing areas flows from areas of low potential radioactivity to those of high potential, then directly to the stack. Most laboratory hoods and laboratory ventilation are exhausted directly to the atmosphere through short stacks after filtration through HEPA filters.

A significant amount of radioactive airborne wastes results from the process of solidifying the liquid waste in the WCF[32]. These airborne wastes are processed through an extensive cleanup system before release to the ICPP stack. This process may be classed mainly as a liquid waste treatment system and is discussed further in Section II.A.3.c. A schematic flowsheet of the WCF off-gas cleanup system

TABLE II-16

COMPARISON OF SOLVENT WASTE BURNER EMISSIONS
TO TOTAL PLANT EMISSIONS
(February, March, April, and May 1970)

| Element | Average Solvent Waste Burner Release (μCi/ml) | Average Plant Stack Release (μCi/ml) | Ratio: Solvent Waste Release to Total Plant Stack Release |
|---|---|---|---|
| Strontium-90 | $2.8 \times 10^{-12}$ | $5.27 \times 10^{-9}$ | 0.0005 |
| Ruthenium-103-106 | $7.9 \times 10^{-11}$ | $5.56 \times 10^{-9}$ | 0.014 |
| Plutonium | $<9.9 \times 10^{-13}$ | $< 1.16 \times 10^{-11}$[a] | 0.085 |

[a] Total alpha, expressed as plutonium.

in shown in Figure II-20. Fine particulates and volatile fission products are carried out of the calciner vessel in the off-gas and must be removed before discharge to the atmosphere.

The first of a series of removal devices for the particulates and volatile fission products is a cyclone which collects the larger particles and discharges them with the solids from the calciner to the storage bins. These solid wastes are discussed in Section II.A.3.e. Next, the off-gas flows through a scrubbing system. The solids collected in the scrubbing system are dissolved in nitric acid (which is added) and recycled back to feed tanks. Volatile ruthenium vapors are absorbed from the scrubbed off-gas by a set of four silica gel beds. These absorber beds also remove some fine particles from the off-gas. The final cleanup device is a set of three HEPA filters with prefilters operated in parallel. The entire off-gas system is maintained at a pressure less than atmospheric. A radiation detector monitors the process off-gas and alarms if the activity reaches unacceptable limits.

The WCF equipment vent system maintains a vacuum on process vessels which are not vented to the process off-gas system, and on sampling stations. About 200 $ft^3$/min of equipment vent gas, consisting mostly of sparge air and transfer jet air, are drawn by a blower through a condenser, mist collector, and HEPA filter before being discharged through the APS to the stack. The radioactivity in the gas stream is measured, together with that of the process off-gas, after the two streams combine.

The process cells are maintained at a slight vacuum to inhibit the release of radioactive materials. Ventilating air flows from the operating areas of the WCF (which do not contain radioactivity) into the process cells before it is discharged to the stack.

TABLE II-17

ICPP RADIOACTIVE AIRBORNE RELEASES

| Year | Volume Discharged ($ft^3 \times 10^9$) | Curies Released |
|---|---|---|
| 1953-1956 | - | 187,200 |
| 1957 | - | 591,600[a] |
| 1958 | - | 1,057,800[a] |
| 1959 | - | 1,275,000[a] |
| 1960 | - | 829,700[a] |
| 1961 | - | 1,155,800[a] |
| 1962 | 60 | 630,485[a] |
| 1963 | 60 | 365,400[a] |
| 1964 | 63 | 84,660 |
| 1965 | 60 | 46,400 |
| 1966 | 63 | 53,470 |
| 1967 | 63 | 21,150 |
| 1968 | 67 | 86,070 |
| 1969 | 60 | 111,400 |
| 1970 | 60 | 148,100 |
| 1971 | 58 | 136,600 |
| 1972 | 59 | 45,890 |
| 1973 | 59 | 4,823 |
| 1974 | 59 | 259,955[b] |

[a] Includes off-gas during RaLa processing. (See Section II.C.10.)

[b] Reflects significant increase in fuel reprocessing activities.

TABLE II-18

1974 ICPP RADIOACTIVE AIRBORNE RELEASE BREAKDOWN

| Nuclide | Curies Released |
|---|---|
| Antimony-125 | 6.3 |
| Cerium-144 | 0.7 |
| Cesium-134 | 0.6 |
| Cesium-137 | 6.7 |
| Cobalt-60 | 0.003 |
| Europium-154 | 0.02 |
| Europium-155 | 0.001 |
| Iodine-129 | 0.1 |
| Krypton-85 | 253,900 |
| Manganese-54 | 0.005 |
| Niobium-95 | 0.008 |
| Plutonium-238 | 0.004 |
| Plutonium-239 | 0.003 |
| Plutonium-239, -240 | 0.0001 |
| Ruthenium-106 | 3.8 |
| Strontium-90 | 3.2 |
| Tritium | 6036 |
| Unidentified alpha | 0.006 |
| Zirconium-95 | 0.004 |
| Total | 259,955 |

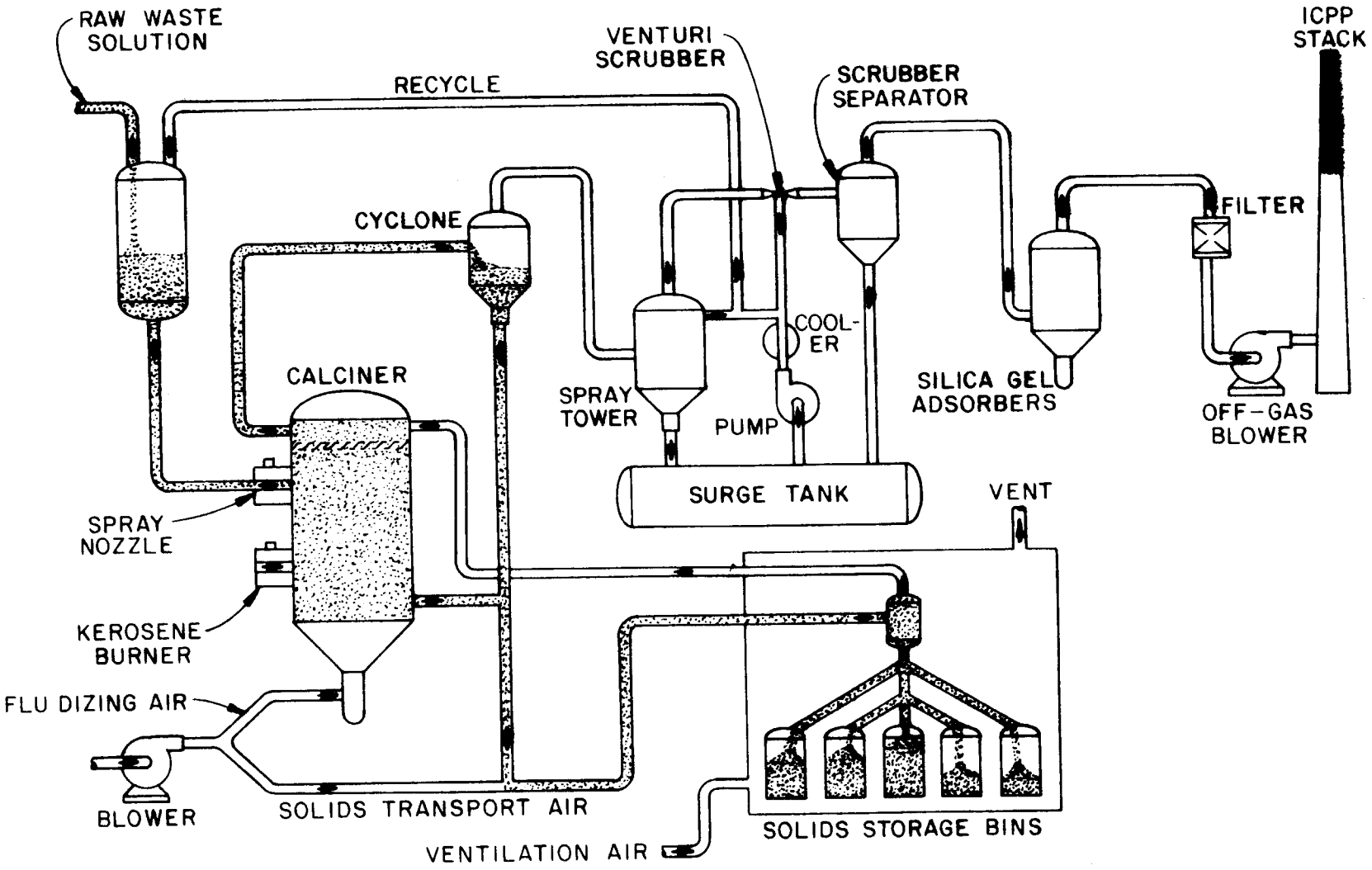


Figure II-20. Schematic Flowsheet of the WCF.

(2) Stack Sampling and Composition

The radioactivity carried in the off-gas systems is monitored at a sampling station provided at the 250-ft-high ICPP stack[33]. The gross activity of the sample stream is measured with scintillation detectors connected to an integrating recorder. A filter assembly collects particulates in the sample stream; radiochemical analysis of the filter paper provides a daily measure of the collected nuclides. Flow rate instrumentation provided with the sampler enables the total activity emission from the stack to be estimated from that determined for the sample stream.

A yearly summary of the airborne waste volumes and of the total radioactivity released through the ICPP stack from 1957 through 1974 is shown in Table II-17. A breakdown of the 1974 release by nuclide is shown in Table II-18. The increased release of radioactivity during 1974 was due primarily to a comparatively high total plant throughput and also the fuel reprocessed was the highly enriched, high burnup type compared with previous fuels. Although the highly enriched, high burnup fuel was reprocessed in 1972, only about one-fifth as much was processed as in 1974. Total annual release of airborne radioactivity (nearly all krypton-85) since 1964 (exclusive of 1974) has ranged from 148,000 curies to as low as 4,800 curies. Future releases, assumming no prolonged processing interruptions, are expected to range between 25,000 and 100,000 curies/year with an average of somewhat less than 50,000 curies/year[a].

Table II-19 shows the effect of decay on the identified radioactive nuclides released in the ICPP airborne effluent for the years 1962 through 1974. Detailed nuclide identification for other years is not available because of past recordkeeping procedures and detection limitations.

(3) Atmospheric Protection System[b]

As already discussed, existing off-gas cleanup systems remove radioactive particulates to well below allowable limits for controlled areas before release to the 250-ft-high plant stack. However, until 1975 all ventilation air from process areas was discharged to the stack without treatment. In 1975, an Atmospheric Protection System (APS) was installed at the Idaho Chemical Processing Plant to minimize the release of radioactive particulate material to the atmosphere from nonroutine occurrences. This system now provides continuous filtration of all building ventilation air from process areas and backup filtration of all process off-gases before they are released to the atmosphere. The APS is located as shown in Figure II-21; a block flow diagram is shown in Figure II-22.

The filter system for the ventilation air consists of a 7-ft-deep fiberglass prefilter in series with separatorless HEPA filters. This system is capable of filtering 150,000 $ft^3$/min of ventilation air from the main fuel processing building, waste disposal building, and waste

[a] See response to Comment X.11.3, Section X for additional information on iodine-129.

[b] See Appendix E, Section 3.B. for additional details on this system.

TABLE II-19

ICPP RADIOACTIVE AIRBORNE EFFLUENT DECAY DATA

| Released in Year | Curies | Decayed through 1/1/76 | | Decayed through 1/1/86 | |
|---|---|---|---|---|---|
| | | Curies | % Remaining | Curies | % Remaining |
| 1962 | 630,400 | 12,600 | 2 | 6,602 | 1 |
| 1963 | 365,400 | 31,800 | 9 | 16,580 | 5 |
| 1964 | 84,660 | 40,340 | 48 | 21,060 | 25 |
| 1965 | 46,400 | 23,450 | 51 | 12,230 | 26 |
| 1966 | 53,470 | 28,570 | 53 | 14,940 | 28 |
| 1967 | 21,150 | 12,330 | 58 | 6,528 | 31 |
| 1968 | 86,070 | 52,100 | 61 | 27,160 | 32 |
| 1969 | 111,400 | 74,130 | 67 | 38,640 | 35 |
| 1970 | 148,100 | 101,500 | 69 | 52,900 | 36 |
| 1971 | 136,600 | 100,900 | 74 | 52,550 | 38 |
| 1972 | 45,890 | 36,660 | 80 | 19,120 | 42 |
| 1973 | 4,823 | 4,016 | 83 | 2,104 | 44 |
| 1974 | 259,900 | 237,900 | 92 | 123,900 | 48 |
| Total | 1,994,000 | 756,300 | 38 | 394,314 | 20 |

calcining building. The prefilter is contained in an underground concrete vault and includes a system for washing the prefilter media. The ventilation gas bypasses the prefilter when washing is required. The prefilter wash is processed in the Process Equipment Waste (PEW) system (described later).

The HEPA filter system for ventilation air is composed of 26 caissons installed in parallel; each caisson contains four HEPA filters. Valving provides isolation for each caisson so that the HEPA filters can be replaced when necessary during operations, without disrupting the system. Filter changeout will be accomplished by contact maintenance using bagging procedures. Three fans (two are sufficient for the system) are provided. The prefilters are located underground in a reinforced concrete vault.

Separate filtration systems, consisting of deep bed prefilters and HEPA filters, process the off-gas containing hydrogen rich and nitrogen oxides. These streams are processed in acid resistant systems because of the high probability of forming acids which would be corrosive to standard materials of construction, such as carbon steel and concrete.

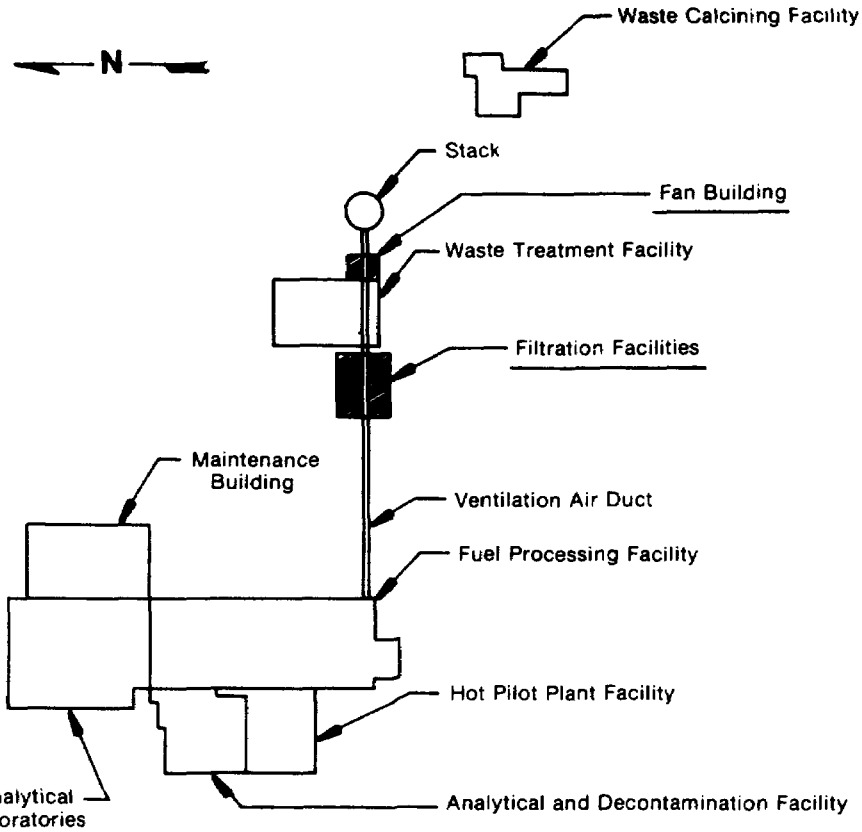


Figure II-21. Location of Atmospheric Protection System at ICPP.

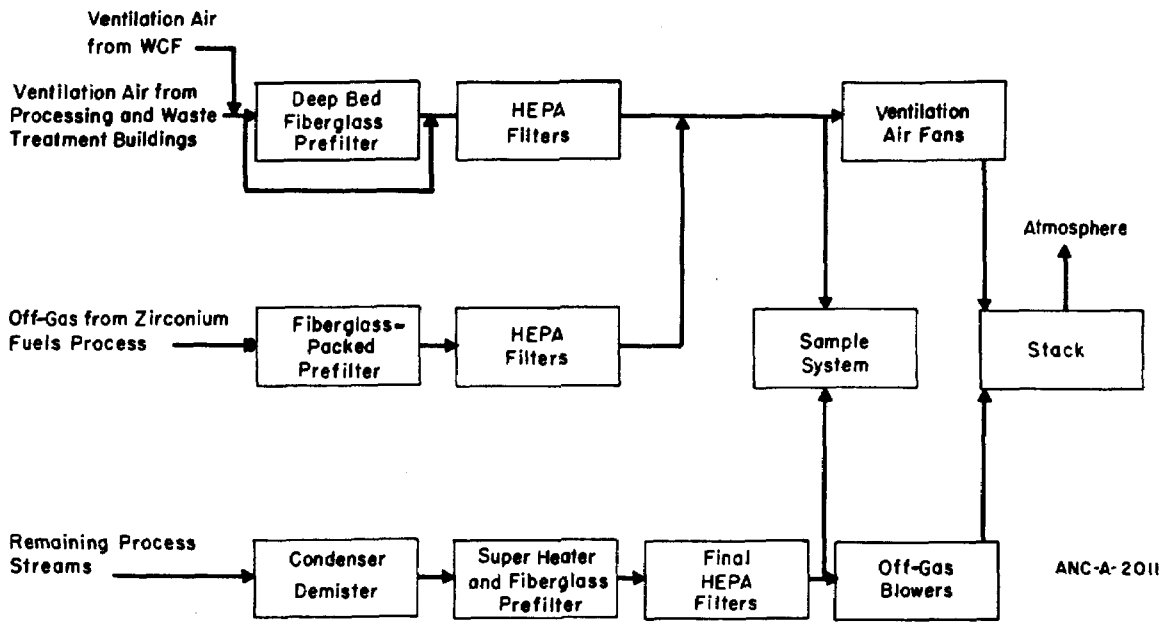


Figure II-22. Atmospheric Protection System Flow Diagram.

Because of its explosive nature the hydrogen rich stream is processed separately from streams containing nitrogen oxides. The hydrogen rich stream is mixed with the ventilation air upstream from the ventilation fans that discharge to the stack. Blowers for the nitrogen oxide off-gas are provided along with a condenser, demister, superheater, and fiberglass prefilter. The nitrogen oxide off-gas passes through three HEPA filters before being discharged to the stack.

b. System for Venting Nonradioactive Airborne Wastes

The main source of nonradioactive components in airborne waste effluent is the WCF, with additional contributions from the four oil-fired boilers used for steam production. Prior to 1972 these boilers used between 80,000 and 150,000 gallons/month of No. 6 fuel oil. A change to No. 2 fuel oil was made in 1972; consumption was about 158,000 gallons/month. Boiler stacks are sampled to measure particulates, sulfur dioxide, nitrogen oxides, and carbon dioxide concentrations.

The ICPP typically releases 3,800 lb of nitrogen oxides and 2,000 lb of carbon monoxide each day from the operation of the WCF. In addition, 50,000 lb of sulfur dioxide and 20,000 lb of particulate material are released each year from oil-fired boilers. (See Section III.B.2.)

The only other airborne effluent from ICPP is the ventilating air from various buildings and about 22 individual stacks from laboratory hoods, etc., where no radioactive contamination routinely is present in the ambient air. This ventilating air is discharged to the environment from each building.

c. System for Disposal of Radioactive Liquid Wastes[a]

Radioactive liquid wastes at the ICPP are generated in various parts of the fuel reprocessing cycle. For example, waste organic solvent is generated in the extraction process to separate uranium from fission products. The high-level liquid wastes that are generated are collected in a tank farm prior to solidification in the WCF. All other liquid radiological wastes are collected in the process equipment waste (PEW) system for further processing before disposal to a discharge well.

(1) Waste Organic Solvent

The nitric acid solution resulting from the fuel dissolution process is purified by a series of operations called "solvent extraction." This process generates approximately 10,000 gallons/yr of contaminated kerosene that must be disposed of under controlled conditions[34].

The waste solvent (kerosene) contains up to $9 \times 10^{-5}$ g of plutonium per gallon, about $2 \times 10^{-3}$ g of uranium per gallon, and approximately $3.8 \times 10^{-4}$ Ci of mixed fission product nuclides per gallon of solution. This activity is reduced by subjecting the waste kerosene to a process called "steam stripping," a flow diagram of which is shown in Figure II-23.

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[a] See Appendix E, Section 3.B. for system improvements completed during 1975-76.

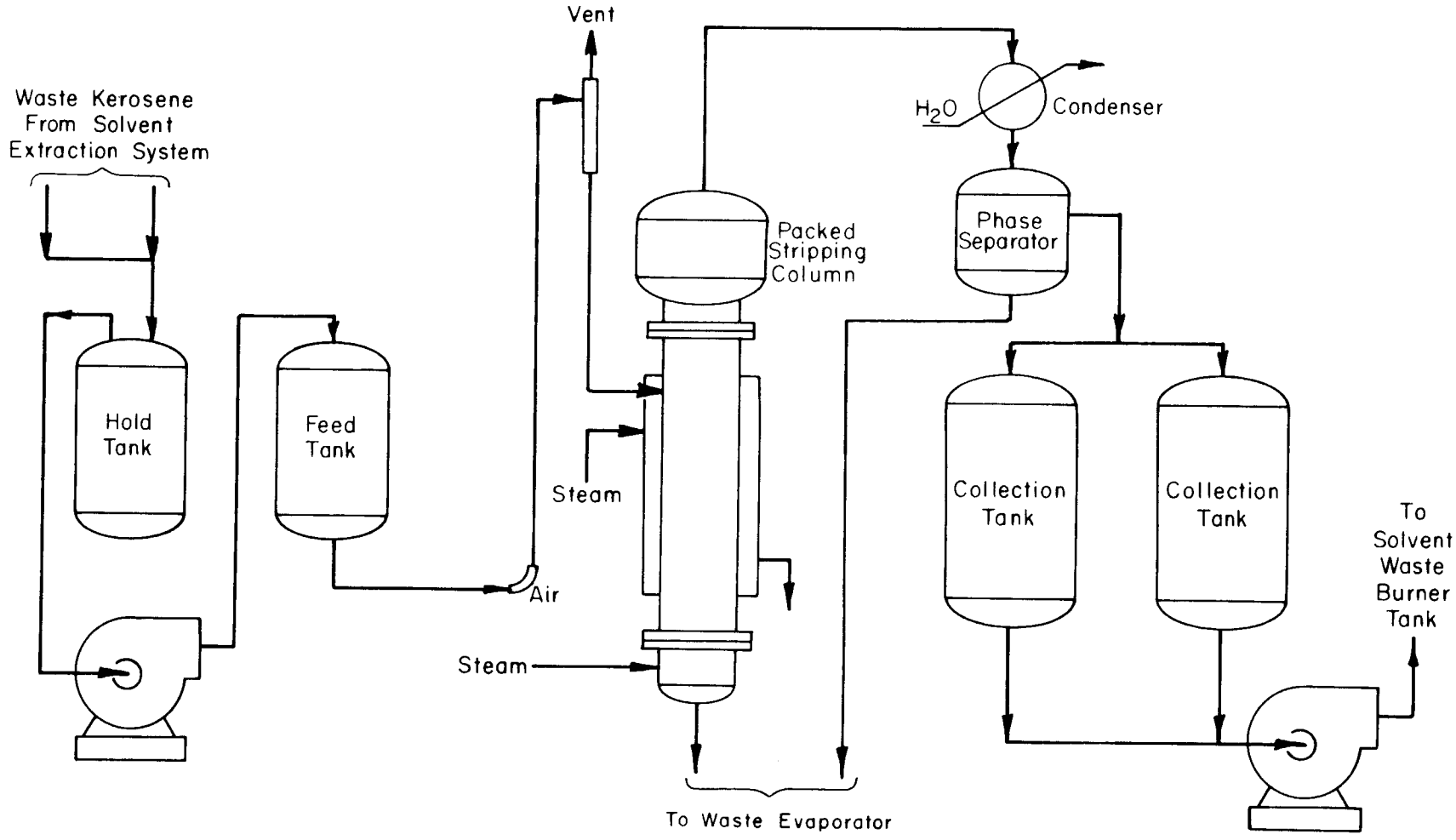


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Figure II-23. ICPP Steam Distillation Flow Diagram.

The waste kerosene from the solvent extraction process is collected continuously in a hold tank, where it is sampled for uranium content once it is full. If its uranium concentration is greater than $2 \times 10^{-2}$ g/gallon ($5 \times 10^{-3}$ g/l), the waste is recycled for further recovery of uranium. If the concentration is less than $1.9 \times 10^{-2}$ g/gallon ($5 \times 10^{-3}$ g/l), the waste kerosene is transferred to the stripper feed tank for processing through the steam stripper. The steam condensate from the steam stripper flows to the process equipment waste (PEW) systems while the solvent flows to one of two collection tanks, where it is monitored for plutonium content.

A collection tank, when filled, is mixed, sampled, and analyzed for alpha activity. All alpha activity above background in this analysis is considered to be plutonium. If the product contains less than the equivalent of 5.7 µg of plutonium per gallon, it is pumped to the solvent waste burner tank, or if the tank is full, to drum storage for burning later. If the total alpha count is higher than 5.7 µg/gallon, the product is recycled to the solvent feed tank.

The contaminants accumulated in the stripping column are removed and sent to the waste evaporator and eventually to the waste tank farm.

In early 1970, a random series of samples from the collection tanks were additionally analyzed by radiochemical procedures; the values obtained for the major nuclides are shown in Table II-20.

TABLE II-20

CONCENTRATION OF MAJOR RADIONUCLIDES IN SAMPLES FROM STEAM-STRIPPED SOLVENT ($\times 10^{-5}$ µCi/ml)

| Date | Strontium-90 | Plutonium[a] | Ruthenium-103/-106 | Alpha |
|---|---|---|---|---|
| February 3, 1970 | 4.84 | <1.1 | 33.8 | - |
| February 23, 1970 | 10.3 | 1.1 | 6.3 | 4.1 |
| March 24, 1970 | 0.78 | <1.4 | 27.6 | 1.4 |
| April 5, 1970 | 1.07 | <0.3 | 33.8 | 0.24 |
| April 12, 1970 | 1.14 | <0.3 | 100 | 0.31 |
| April 17, 1970 | 0.59 | <0.8 | 4.1 | 0.82 |
| April 21, 1970 | 0.13 | <0.3 | 20.4 | <0.2 |
| April 30, 1970 | 0.38 | <0.3 | 12.3 | <0.2 |

[a] Plutonium detection limit is $0.33 \times 10^{-5}$ µCi/ml.

(2) Tank Farm

The high-level radioactive wastes generated from the fuel recovery process contain more than 99% of the radionuclides, excluding noble gases, contained in the fuel elements. Numerous radionuclides are contained in the waste when first generated, but the radionuclides of major concern in wastes to be stored for long periods of time are the isotopes of cesium, strontium, cerium, uranium, and plutonium. These isotopes are of concern because of their long half-lives and radiotoxicity. The actual composition of the waste varies greatly depending on the type of fuel being processed, the amount of time that the fuel was irradiated in the reactor, and the length of time the fuel is stored prior to processing. The volumes and typical radiochemical composition of high-level wastes stored at ICPP are shown in Tables II-21 and II-22.

These high-level radioactive wastes are stored in large underground stainless steel tanks until the wastes are transferred to the WCF where they are solidified. These storage tanks are located in an area east of the main processing plant called the "tank farm." Because of the special requirements associated with storing high-level radioactive liquid waste, this system is described in detail.

TABLE II-21

HIGH LEVEL RADIOACTIVE LIQUID WASTE

(December 1974)

| Tank No. | Waste Type | Contents (gal) |
|---|---|---|
| 300,000-gal tanks | | |
| WM-180 | Second and third cycle | 281,400 |
| WM-181 | Spare for waste diversion system | 64,000 |
| WM-182 | Aluminum and zirconium | 282,700 |
| WM-183 | Aluminum and electrolytic | 56,400 |
| WM-184 | Second and third cycle | 283,000 |
| WM-185 | Aluminum and zirconium | 278,000 |
| WM-186 | Second and third cycle | 283,000 |
| WM-187 | Aluminum and zirconium | 277,000 |
| WM-188 | Aluminum and zirconium | 218,200 |
| WM-189 | Aluminum and zirconium | 167,000 |
| WM-190 | Spare | 0 |
| Total | | 1,346,700 |

TABLE II-22

TYPICAL RADIOCHEMICAL COMPOSITION OF TANK FARM INVENTORY AS OF SEPTEMBER 26, 1973

($\mu$Ci/ml)

| Component | Aluminum-Zirconium Blend | Aluminum-Electrolytic Blend | Stainless Steel Sulfate | Second and Third Cycle |
|---|---|---|---|---|
| Cobalt-60 | 1.3 | 0.51 | - | 0.01 |
| Zirconium-95 | 4.87 | - | ~0 | 0.10 |
| Niobium-95 | 6.38 | - | ~0 | 0.0465 |
| Ruthenium-106 | 76 | 31 | 0.222 | 4.02 |
| Antimony-125 | 26.9 | - | - | 1.30 |
| Cesium-134 | 178 | 16.9 | 67.5 | 0.695 |
| Cesium-137 | 833 | 550 | $1.32 \times 10^{4}$ | 100 |
| Cerium-144 | 710 | 202 | 0.460 | 1.19 |
| Europium-154 | 13.0 | 495 | - | 0.330 |
| Strontium-90 | 476 | 522 | $1.22 \times 10^{4}$ | 90.7 |
| Tritium | 0.368 | 21 | - | 0.065 |
| Neptunium (total g/l) | $0.336 \times 10^{-9}$ | - | - | - |
| Uranium (total g/l) | $0.378 \times 10^{-7}$ | $0.34 \times 10^{-7}$ | - | $2.10 \times 10^{-6}$ |
| Plutonium (total g/l) | $0.419 \times 10^{-7}$ | $0.73 \times 10^{-8}$ | - | $0.37 \times 10^{-7}$ |
| Gross beta | 4,840 | - | - | 340 |

The tank farm contains 15 stainless steel vessels, nine of which have individual volumes of 300,000 gallons, two have individual volumes of 318,000 gallons, and the other four have a volume of 30,000 gallons each. Each of the nine 300,000-gallon tanks and the two 318,000 gallon tanks is contained in a concrete vault, the top of which is about 10 ft underground.

A schematic diagram of one of the 300,000-gallon tanks is shown in Figure II-24. Each large tank is 50 ft in diameter with a 21-ft wall and a 32-ft height from the floor to the top of the hemispherical roof. The floor is flat and the sides are vertical. The vessel floors and lower 8 ft of the sides are made from 5/16-in.-thick stainless steel plate, the upper 13 ft of the sides is 1/4-in.-thick stainless steel plate, and the hemispherical roof is 3/16-in.-thick stainless steel plate. The tanks are designed for a liquid with a specific gravity of 1.4, for a temperature of 200°F, a maximum pressure of 1 atmosphere, and a vacuum of 3.9 in. water. Eight of the eleven large tanks are equipped with interior cooling coils on the floor and walls.

The 300,000-gallon waste tanks and the associated concrete secondary containment vaults have been analyzed for their dynamic response to a hypothetical earthquake occurring at the INEL. This analysis was accomplished using the STRAP-D (STRuctural Analysis Package - Dynamic) computer code. Ground acceleration histories from four of the largest West Coast earthquakes were used as models for the calculations: the 1940 El Centro, 1949 Olympia, 1952 Taft, and 1966 Parkfield. The May 18, 1940, El Centro earthquake had the largest localized energy, with accompanying ground acceleration of any earthquake ever recorded in the continental United States.

The results of analysis show that the waste storage tanks and vaults will withstand the severe ground shaking accompanying very strong earthquakes. Even when subjected to the 1940 El Centro earthquake record scaled to a peak ground acceleration of 0.5 g, the waste tanks were stressed only to 21,300 psi. This is only 59.1% of the 36,000 psi required to cause tank failure. Using the unscaled 1940 El Centro earthquake record, which had a peak ground acceleration of 0.33 g, only 50.4% of yield stress in the tanks was produced. This latter acceleration, 0.33 g, corresponds to the acceleration expected at the ICPP from a maximum hypothetical earthquake of Richter magnitude 7-3/4 on the Arco fault at a point 15 miles from ICPP. It does not take into account the appreciable energy attenuation which likely would occur because of the particular geological structure of the Snake River Plain.

Under the same conditions, analysis of the reinforced concrete vaults housing the storage tanks showed that a peak ground acceleration of 0.5 g would cause a peak stress of 87.7% of yield stress. The unscaled 1940 El Centro record imposed only 79% of yield stress of the vaults.

It is emphasized that an earthquake producing a 0.33-g peak ground acceleration at ICPP is considered a purely hypothetical upper-limit

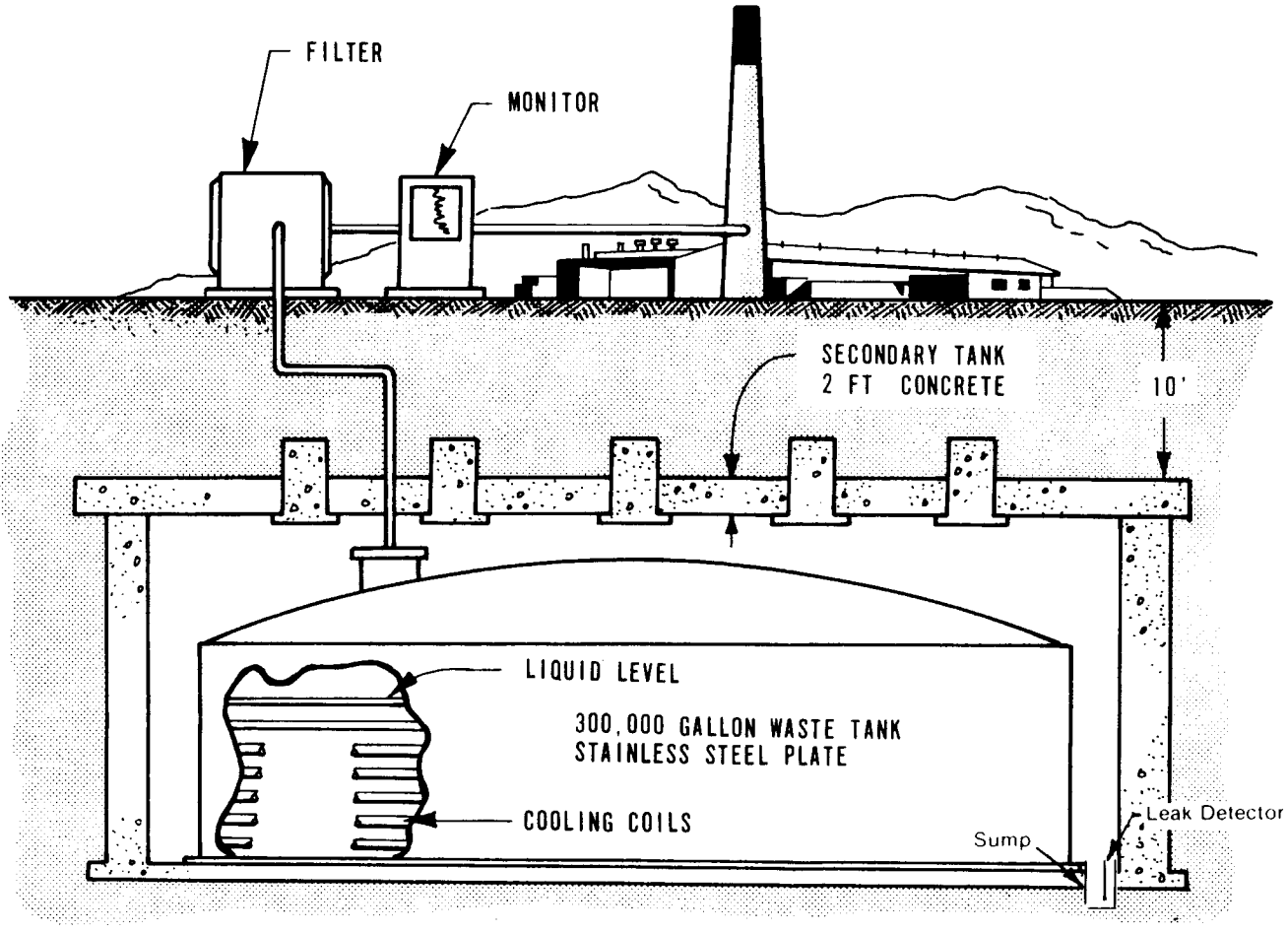


Figure II-24. Schematic Diagram of Typical 300,000-gallon Liquid Waste Tank (not to scale).

event which has not been exceeded in magnitude by any known earthquake. The Arco fault has not been seismically active in historic time. The Snake River Plain is believed to be locally aseismic. (See Section II.C.7).

The liquid levels in the 300,000-gallon tanks that contain highly radioactive waste are monitored continuously. A level indicator in each tank is set to alarm when the volume reaches 285,000 gallons. This alarm sounds in the control house and the main process building.

Tank pressure also is measured and transmitted to the control panel. If the relief valve is activated, the pressure is released to a line that vents directly to the stack. The normal tank venting system is connected to the process vessel off-gas system in the main plant, which is a filtered system.

Specific gravity of the liquid waste is measured continuously, and the value is transmitted to a recorder which has an alarm in the control house and in the main process building. The alarm is activated at a specific gravity of 1.35. The tanks are designed to contain solution with a specific gravity of 1.40.

Multiple temperature points in the tanks provide individual temperature measurements for each 2 ft of vertical wall height and for the tank bottom. In addition, a set of thermocouples is provided on the opposite side of each tank. The temperature of each tank is recorded continuously on multiple point recorders. A high-temperature alarm is installed for each tank with alarms at the control house and at the main process building. Normally the wastes are well below the high-temperature alarm point.

Eight of the eleven 300,000-gallon tanks contain a 4.7 million-Btu/hr-capacity closed-loop cooling system consisting of 30 coils of stainless steel pipe around the interior walls and floor of the tanks. The water pressure in the cooling coils is greater than the pressure in the waste tanks so that any break which might occur in the cooling water coils would result in leakage into the tank rather than into the cooling water. The tanks with cooling coils have been in operation since 1953, and no leak has occurred in any of the cooling systems to date. Nevertheless, a radiation monitor is installed on the return coolant line from the tank. The monitor will alarm in the event the cooling water should become contaminated. Any specific leaking coil can be located and isolated by closing the individual valves on the 30 cooling coils in each tank, and then opening these valves one at a time and observing the radiation monitor. Any contaminated water detected can be transferred to the waste evaporator system for processing and fresh water can be added to the cooling coils.

The tanks are also connected to reflux condensers which condense the vapors if the tank contents should overheat. These condensers are stainless steel shell-and-tube units contained in concrete housings in the tank farm area. The condenser pits have sumps equipped with jets to transfer leakage back to one of the waste tanks; however, use of the condensers normally is not necessary.

Each of the 300,000-gallon storage tanks is contained in an individual concrete vault which serves as a secondary containment barrier if waste leaks from the tank. The vault is constructed of reinforced concrete approximately 2 ft thick. The vaults are either octagonal or square and are about 60 ft across and 33 ft tall.

Each tank within its vault rests on a thin layer of sand on top of a concrete pad at the bottom of the vault; the bottom of the vault rests on bedrock.

The vaults generally have sumps to collect any leaking liquid; the sumps are 1 to 3 ft deep and either 1 or 2 ft square. An increase in the level in the sump indicates that the tank contents are leaking or that water from outside the vault has leaked in. Any liquid in the sumps can be returned either to the tank or to the main plant for processing. These sumps each have a measuring device which indicates the liquid level in the sump. The measuring unit is connected to a multipoint recorder that continuously records the liquid levels in all of the sumps. The readings for the sumps are recorded in a logbook once each 8-hr shift. The system also is connected to an alarm which sounds in the control house and in the main plant if the level exceeds a predetermined value (15 in.). Water in the vault sumps can be sampled manually by submerging a bottle attached to a handline. The samples obtained are analyzed for radioactivity.

One of the tanks containing cooling coils always remains empty to serve as a spare; thus, if a leak develops, the contents of the leaking tank can be transferred to the spare by existing jets and piping.

Three of the 300,000-gallon tanks that do not contain cooling coils are used to store radioactive liquid wastes that do not generate any appreciable heat because the concentration of fission products is too low. One of these three tanks is retained as a spare in the event that failure of a process vessel containing radioactive solution contaminates normally nonradioactive cooling water. If this occurs the contaminated cooling water is diverted to the spare tank and later processed in the main plant to remove the radionuclides before the water is released to the discharge well.

Four 30,000-gallon stainless steel tanks are buried horizontally. They are 12 ft in diameter and have 38-ft-long straight sides. The shells and heads of these tanks are 0.7 and 0.6 in. thick, respectively. The tanks also are equipped with cooling coils and are connected to a shell-and-tube condenser to remove heat produced by the decay of radionuclides. The tanks rest on a concrete pad but are not surrounded by a vault. A curb surrounds the concrete pad and a sump equipped with a level alarm collects any leakage from the tanks. A 24-in.-diameter pipe extends from the surface of the ground to the sump so that a portable unit can be used to empty the sump if necessary. The four 30,000-gallon tanks were used in the past to store wastes from early processes used at the ICPP. All of these tanks have now been emptied.

All underground waste lines (9,000 ft) in the tank farm are stainless steel. All lines that carry radioactive waste have secondary containment which includes stainless steel lined concrete encasements, secondary steel pipe with spacers, or tile pipes with spacers encased in concrete. This secondary containment provides two safety features:

(a) It prevents contact of the primary waste line with the soil to avoid underground corrosion.

(b) In the event a leak develops in the waste transfer line, the radioactive waste is contained within the secondary containment system and release of the contaminated solution to the soil is minimized.

The lines carrying radioactive waste go through valve pits and diversion boxes constructed of concrete with a stainless steel liner. The secondary encasements are sloped to drain to valve pits and diversion boxes which are provided with collection sumps for sampling possible leakage. Continuous leak detecting equipment is being installed (1977) in all sumps. This equipment will read out and alarm at a control building (see Appendix E for details).

Although no leakage of radioactive waste has occurred from any of the tanks since startup in 1951, some waste from two of the cooled 300,000-gallon tanks discharged to the tank vaults in March 1962 as a result of an accidental siphoning action following the jetting of water from the vaults into the tanks. Following this event, the jet systems on all of the tanks were equipped with a siphon break to avoid creating a siphoning action, and the contaminated solution in the vaults was returned to both tanks. No release of contaminated solution to the ground occurred. During periods of surface runoff resulting from melting snow or heavy rains, five of the 11 vaults containing 300,000-gallon waste storage tanks collect water from in-leakage through the top of the vault. This water periodically is transferred into the tank or to the waste evaporator for processing. In an effort to eliminate this in-leakage, the level surface of the tank farm will be graded to slope away from the center, and drain lines will be installed to carry the runoff water away from the tank farm area.

Several other improvements in the tank farm system are also under consideration. These include:

(a) Installing a more reliable and accurate electronic depth measuring instrument for each tank and for one sump in each vault; then improvements will be in addition to the present system

(b) Modifying the concrete shielding plugs to simplify sampling for any liquid in the tank vaults

(c) Adding an air sparge to each sump to provide mixing so that a representative sample is obtained

(d) Replacing some defective thermocouples in the temperature measuring system

(e) Consolidating instrument readouts for all tanks into one building that has constant surveillance

(f) Installing a monitoring system in the diversion box sumps.

Additional details of these improvements are found in Appendix E.

(3) Waste Calcining Facility (WCF)

The high-level radioactive liquid wastes stored in the tanks at the tank farm are converted to a granular solid in the WCF[35,36], shown in the aerial photograph in Figure II-25. The operating philosophy at the ICPP is to solidify the liquid wastes, then store the solids; this procedure eliminates the need to build any more liquid waste storage tanks.

Solidification of the liquid wastes begins in the fluidized-bed calciner, in which the relatively mobile liquid is converted to a less mobile, safer to store solid form. Solidification also results in a 7-to-1 reduction in the volume of waste, thereby reducing the long-term storage costs attributable to the radioactive wastes. In the solidification process, the high-level radioactive waste solution is sprayed into a fluidized bed of solidified waste granules. The granules are maintained at a temperature of 400 to 500°C. A schematic flowsheet of the complete process, including off-gas cleanup and calcine solids storage, is shown in Figure II-20. As the spray droplets contact the hot granules, the water is driven off, leaving a coating of dried radioactive solids on the granules. The 0.3- to 0.7-mm-diameter granules are fluidized as the blower forces air into the bottom of the calciner vessel. Heat is provided for the endothermic reactions in the calciner by burning kerosene directly in the fluidized bed. Fine particles are swept out the top of the calciner vessel along with the off-gas to a cyclone, where most of the fines are removed and added to the stream of solids being transferred pneumatically from the calciner vessel to the solids storage bins. The solids are discussed later in Section II.A.3.e. The off-gas from the process is cleaned in the off-gas cleanup system of the process before release to the ICPP stack as discussed in Section II.A.3.a.

The largest volume (20 million to 60 million gallons/yr) of liquid wastes generated from operation of the WCF are service wastes consisting of cooling water and condensate from the steam system. These liquids are normally nonradioactive and are discharged to the service waste system which is discussed later in this section. About 100,000 gallons/yr of radioactive liquids collected from decontamination of process equipment, process cells, and from floor drains are stored in a waste tank, then processed through the PEW system.

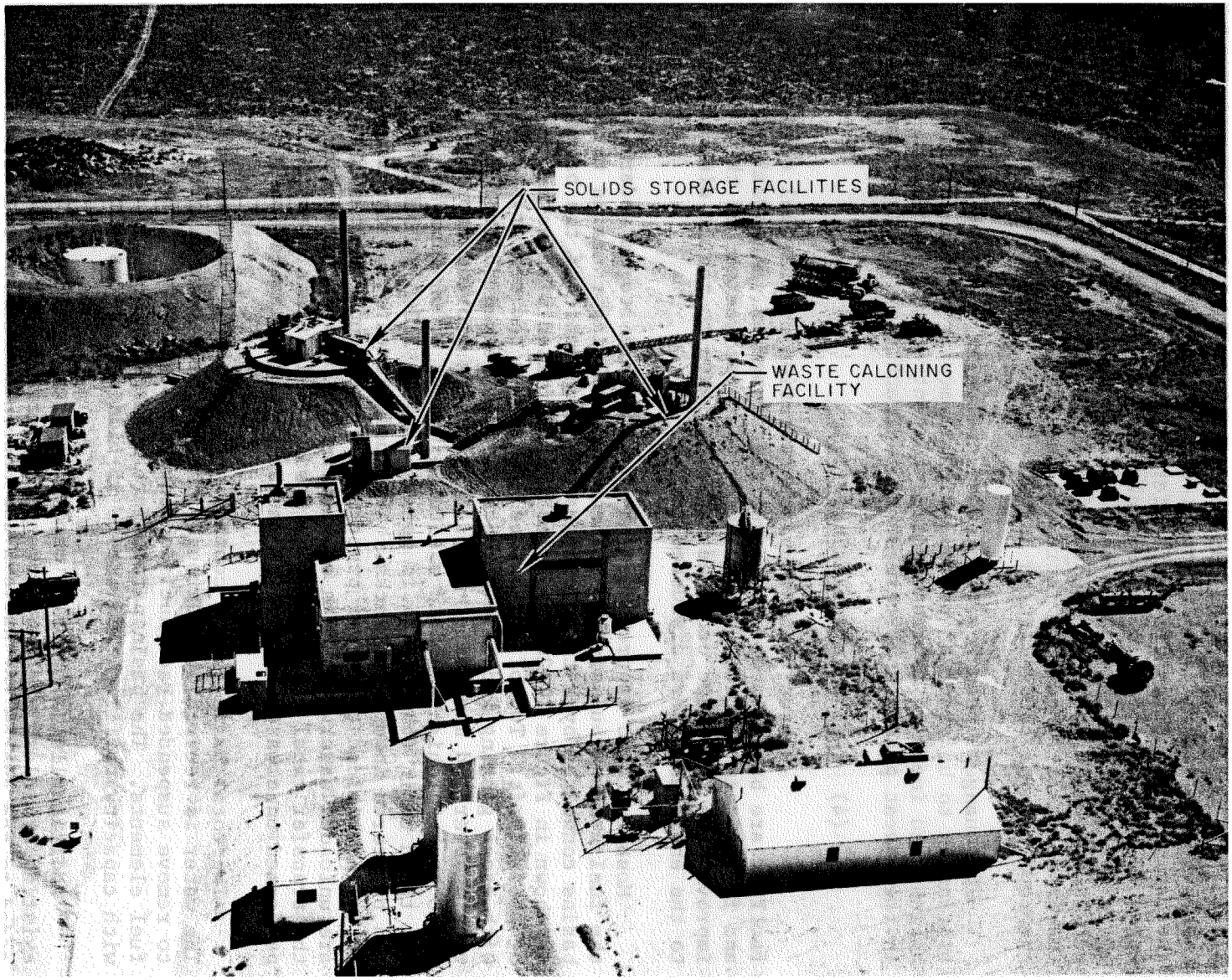


Figure II-25. Aerial View of WCF.

The major change scheduled for the WCF[a] is its replacement with a new facility. An environmental impact statement has been written describing this proposed facility[37]. The process will be similar in concept to the existing process. The new facility layout contains modifications expected to reduce radiation exposures to maintenance personnel. Also, the proposed off-gas system assures the lowest practicable release of radionuclides in the process off-gas. Liquid wastes anticipated in the future will contain increased radionuclide concentrations from the reprocessing of fuels with higher burnup.

The changes proposed for the new calcining facility and the additional filtration to be provided by the APS will more than compensate for the anticipated increase in radionuclide concentration in the fuel and result in the lowest practicable release of radioactivity to the environment.

(4) Fuel Storage Basin Facility

Wastes created by the operation of the fuel storage basin facility are basin water discharge, filter washes, decontamination waste, and floor drain waste. The character of these wastes and the process improvements that have occurred over the years to reduce discharges to the environment are discussed below.

Most fuels to be processed at the ICPP are stored underwater in the fuel storage building. The E-shaped building contains three storage basins connected by a transfer canal. A schematic of the basin system is shown in Figure II-26. The basins are filled with water to a depth of about 19 ft. Two of the basins (the north and center) are covered with steel grating and have buckets of fuel suspended from yokes which ride on overhead monorails. These two basins provide storage for about 1,000 buckets which can hold a total of about 4,000 separate fuel elements. The third basin (the south) is open, and some 2,000 to 3,000 fuel elements can be stored in special racks. The fuel elements, which are transported in large shielded casks for protection of personnel against radiation, are unloaded underwater in a small transfer pool and transferred via the transfer canal to the storage basins. All transfer operations are performed underwater to provide radiation shielding for operating personnel.

The total basin system contains about 1.5 million gallons of water. The water is recirculated through filters and ion-exchange resin columns to remove suspended radionuclide contaminants resulting from leaking fuel elements. The basin particulate filter system will soon be installed with capacity to filter the entire 15 million gallons within 24 hours.

Additionally, a chloride removal system will be installed to protect existing stainless steel equipment from corrosion. (The chlorine is added to the system for basin algae control.) During regeneration of the filters, the regenerating solution will be transferred to the 25,000-gallon sludge collection tank wherein the particulate will collect and the liquid will decant to the PEW system.

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[a] See Appendix E, Section 3.B. for additional details on the new waste calciner facility.

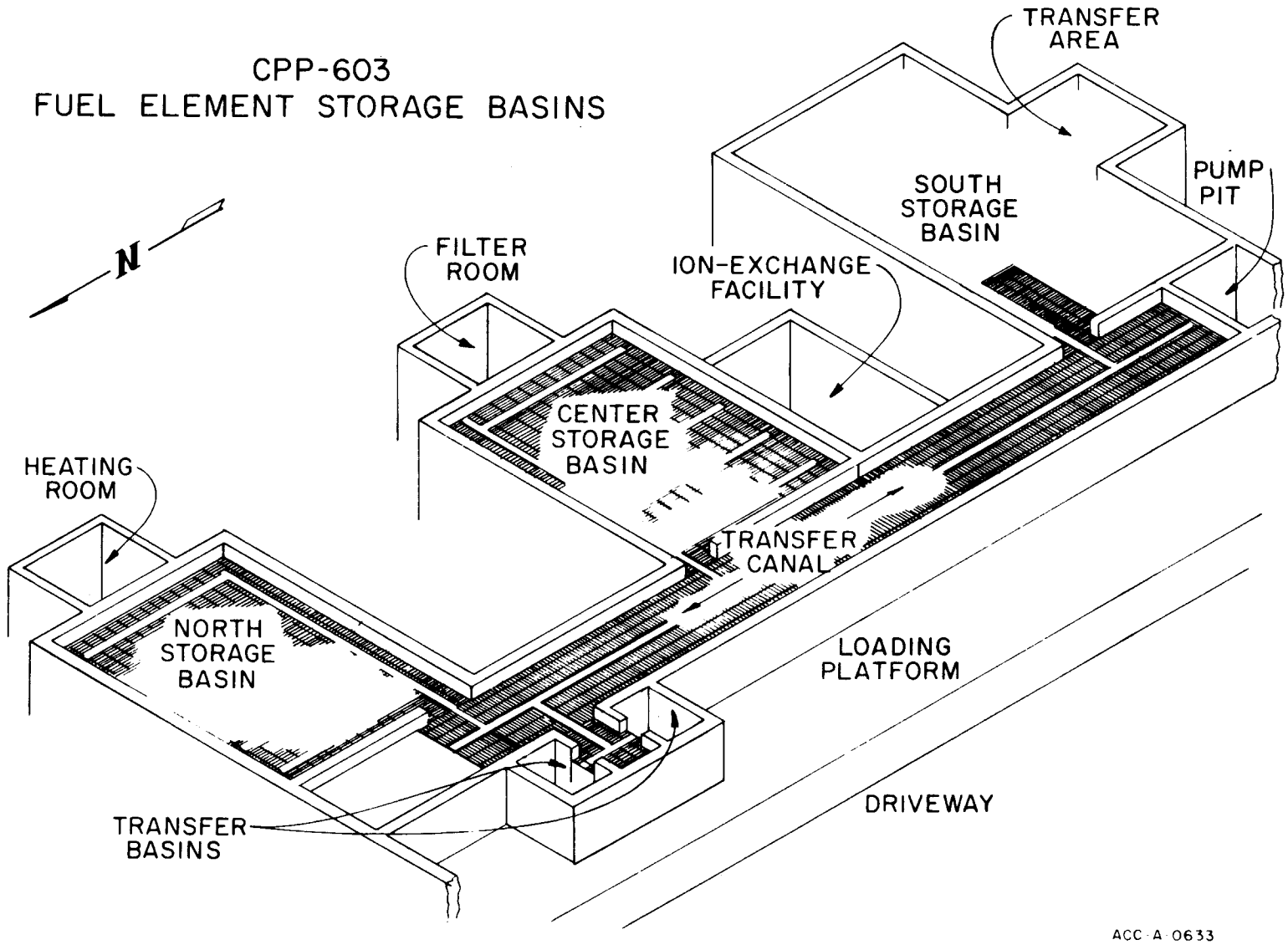


Figure II-26. ICPP Fuel Element Storage Basins.

The basin was designed originally to receive fresh water continuously while discharging an equal volume of water through a pipe to an underground manhole outside and west of the building. The water percolated down through the earth materials which removed radionuclides by ion exchange with the soil particles (similar to the reaction occurring in a conventional water softener). The amount discharged varied from about 60,000 gallons to several hundred thousand gallons per month. The total amount of radioactivity released to the ground from this source between 1951 and 1966 was about 500 Ci, which included 33 Ci of strontium-90 and 34 Ci of cesium-137.

Starting in 1963, the basin water being released to the ground was processed through an ion-exchange system to remove radionuclides prior to release. This treatment, which continued until 1966, reduced the concentration of radionuclides in the water going to ground to meet applicable release standards[7]. In 1966, discharge was discontinued and the effluent from the ion-exchange columns was returned to the basin in a closed system recycle.

The filters that remove particulate matter from the recirculating water are coated with a layer of diatomaceous earth which removes the suspended particles. A significant pressure drop eventually occurs across the filters as the particulate matter plugs in the pores of the diatomaceous earth; the filters then are backwashed and fresh diatomaceous earth is added. The discarded diatomaceous earth until 1966 was discharged as a sludge to an underground concrete pit containing several baffles. The solids settled to the bottom of the pit and the clear liquid was pumped to an underground manhole on the east side of the building. The water percolated down through the earth materials and the small amounts of radionuclides contained in the water were removed by ion exchange with the soil materials. An estimated 20 Ci of radioactivity were released to the ground from this source. In 1966 discharge of the liquid to the ground was discontinued. The contaminated water now is returned to the plant for treatment via an underground line and the solids are collected in a new 25,000-gallon sludge storage tank.

A stainless steel decontamination pad in the fuel storage building is used occasionally for the decontamination (usually by steam and organic solvents) of fuel shipping casks or other significantly contaminated pieces of equipment. The contaminated steam condensate and wash water originally were discharged to the underground manhole east of the building. Discharge of this contaminated water was discontinued in 1968; the water now is transferred via an underground line to the main plant for treatment.

The floors within the fuel storage building are washed periodically with water to remove dirt brought in by wind and cask transport vehicles. Occasionally radioactive contamination resulting from handling of fuel casks is contained in the water. Originally this wash water entered floor drains and was discharged to both the east and west side manholes for percolation through the earth materials. In 1972, the discharge from the floor drains was diverted from the manholes to an underground pipeline for transfer to the main plant for treatment.

Over the years dust has blown into the building when the large doors are opened to allow entry of cask carriers. The dust settled to the bottom of the basins forming a layer of sludge. In addition, corrosion of steel and aluminum structures underwater has added to the accumulation of sludge. This sludge has acted as a scavenger to remove significant amounts of radionuclides from the water and consequently it is also contaminated.

In 1972, a 25,000-gallon stainless steel tank contained in a concrete vault was installed underground near the fuel storage building to collect the sludge. A vacuum cleaning system with connections to each basin was provided to transfer sludge from the bottom of the basin to the 25,000-gallon tank. After the solids settle in the tank, the supernatant liquid is either returned (through a filter) to the basin or it transferred via an underground pipeline to the main plant for treatment. In addition to sludge from the basin floors, the used diatomaceous earth from backwashing the filters also is discharged to the 25,000-gallon tank. After the diatomaceous earth settles, the clear liquid is returned to the basin or routed to the main plant for treatment. The 25,000-gallon tank is estimated to have sufficient capacity to hold all of the sludge removed for the next 20 years. At that time a new tank will be built.

At some future date, an off-gas cleaning system may be constructed and connected to the 25,000-gallon tank. Acid could then be added through existing lines to dissolve any uranium, fission products, and the acid soluble portion (~50%) of the sludge. This solution would then be transferred to the main plant via an underground pipeline for recovery of the uranium and calcination of the fission product waste.

At present all liquid waste that is produced at the fuel storage basin is either recycled to the basin or routed to the main plant through an underground stainless steel line. No liquid waste is being released to the ground, nor will any significant amount be released intentionally in the future.

(5) Peach Bottom Storage Facility

The Peach Bottom Fuel Storage Facility is located within the confines of the ICPP security fence and north of the fuel storage basin. The storage facility consists of 47 storage vaults spaced on 30-ft centers in a square array and covers an area approximately 200 by 350 ft.

Each vault is approximately 20 ft deep by 30 in. in diameter and accommodates one complete shipment of Peach Bottom I Core 1 fuel. The vaults are lined with carbon steel casing with 2 ft of sand cement grout at the bottom to seal the vault and provide a base for the fuel. A reinforced concrete pad 8 ft by 14 ft by 1 ft thick is poured around the top of each vault to provide a flat working surface. After the fuel is inserted into the vaults, top shielding is provided by an offset, 4-ft-thick concrete plug. The storage vaults are sealed for containment, security, and inventory control of the spent fuel by welding a steel plate on the top of each vault.

All fuel elements are individually sealed in canisters containing an inert helium gas atmosphere. Each canister has a Type 6061 aluminum alloy outer wall and mild-steel inner liner. The inner liner is 10 ft long by 0.06 in. thick and has an outer diameter of approximately 4.1 in. After inserting a fuel element, a magnetic pressing process is used to seal the top of each canister around an aluminum cap having a lifting knob and a double O-ring seal; this forms an airtight unit. The canisters are sealed at atmospheric pressure and helium-leak tested before being placed in the storage pool at the Peach Bottom Power Station in Pennsylvania. Any leaking fuel element canisters are placed inside salvage canisters of the same construction and configuration.

(6) Process Equipment Waste (PEW) System

The PEW system at ICPP is provided to collect, concentrate, store, and process all of the low-to-intermediate-level radioactive liquid waste solutions. These radioactive waste solutions are generated in large volumes, typically 50,000 to 100,000 gallons/month, and consist mostly of water mixed with caustic, acid, and radioactive contamination. The contamination level of these solutions is relatively low, compared with the high-level wastes produced as a byproduct of fuel processing, but too high to be discharged to the environment; consequently these solutions are contained and processed at the ICPP. Since it would be extremely costly to store large volumes of these dilute wastes, the volume is periodically reduced by evaporation.

All vessels, piping, and other equipment associated with this system are constructed of stainless steel. Except for some of the underground transfer lines, all equipment is contained within concrete rooms (cells). Transfer lines between systems are located underground and are also of stainless steel. The main underground transfer lines are encased inside other stainless steel pipe or ceramic tile pipe surrounded by concrete. These pipe encasements can be sampled to check for solutions which might have leaked from the main transfer lines.

PEW solutions are collected in four 5,000-gallon tanks from three different areas: the main fuel processing and laboratory buildings, the headend process plant, and the west side collection systems. These solutions are sampled for uranium, then transferred to an interim storage vessel and finally to the waste evaporator. An 18,000-gallon vessel located in a cell below the waste evaporator building is used for interim storage. Liquid waste transported to ICPP by truck from other INEL installations also is collected in this vessel. The concentrated evaporator solutions (bottoms) are drained to interim storage, then transferred to the tank farm for storage until calcination. The evaporator condensate is washed, condensed, collected, and sampled for radioactivity concentration. If the radioactivity is above $6 \times 10^{-5}$ μCi/ml, the condensate is processed through ion-exchange columns for additional purification. The condensate then passes through another activity monitor and is either diverted back to interim storage or to service waste, depending upon the activity. (See Section II.A.3.d for disucssion of "service waste.")

The steam condensate from the waste evaporator heat exchanger is monitored, automatically pumped to the service waste monitoring station, then sumped to the disposal well. The average amount of solution collected in the PEW vessels is approximately 2.3 million gallons/yr, of which 50,000 gallons/yr goes to waste storage as concentrated waste and the remainder goes to service waste. The average radionuclide composition of the solutions (evaporator condensate) going to service waste is shown in Table II-23. A flowsheet of the PEW system is shown in Figure II-27.

TABLE II-23

TYPICAL RADIOCHEMICAL COMPOSITION OF EVAPORATOR CONDENSATE

| Radionuclide | Average Concentration ($\mu$Ci/ml x $10^{-4}$) |
|---|---|
| Gross beta (mainly tritium) | 11.00 |
| Cesium-137 | 1.50 |
| Strontium-90 | 1.40 |
| Ruthenium-106 | 0.68 |
| Cerium-144 | 2.00 |
| Zirconium-Niobium-95 | 0.42 |
| Antimony-125 | <0.28 |
| pH | 1-2 |

The west side waste system is a separate system for collecting cold (nonradioactive), low-level, and intermediate-level radioactive liquid waste solutions from office and laboratory buildings west of the main fuel processing building. This system consists of three 5,000-gallon vessels and is connected to the PEW system.

Solutions from the nonradioactive tank are pumped automatically to service waste via a monitoring station, if contaminated however, they may be transferred to interim storage via the low-level tank.

When the low-level tank is full, solutions are sampled for uranium accountability then transferred through interim storage to the waste evaporator. If the waste evaporator should become inoperable and interim storage were full, the low-level solution could be routed to the tank farm via the intermediate-level collection tank.

Solutions in the intermediate-level tank also are sampled, then normally transferred to interim storage via the low-level tank. These solutions also can be transferred directly to the tank farm rather than be processed through the waste evaporator.

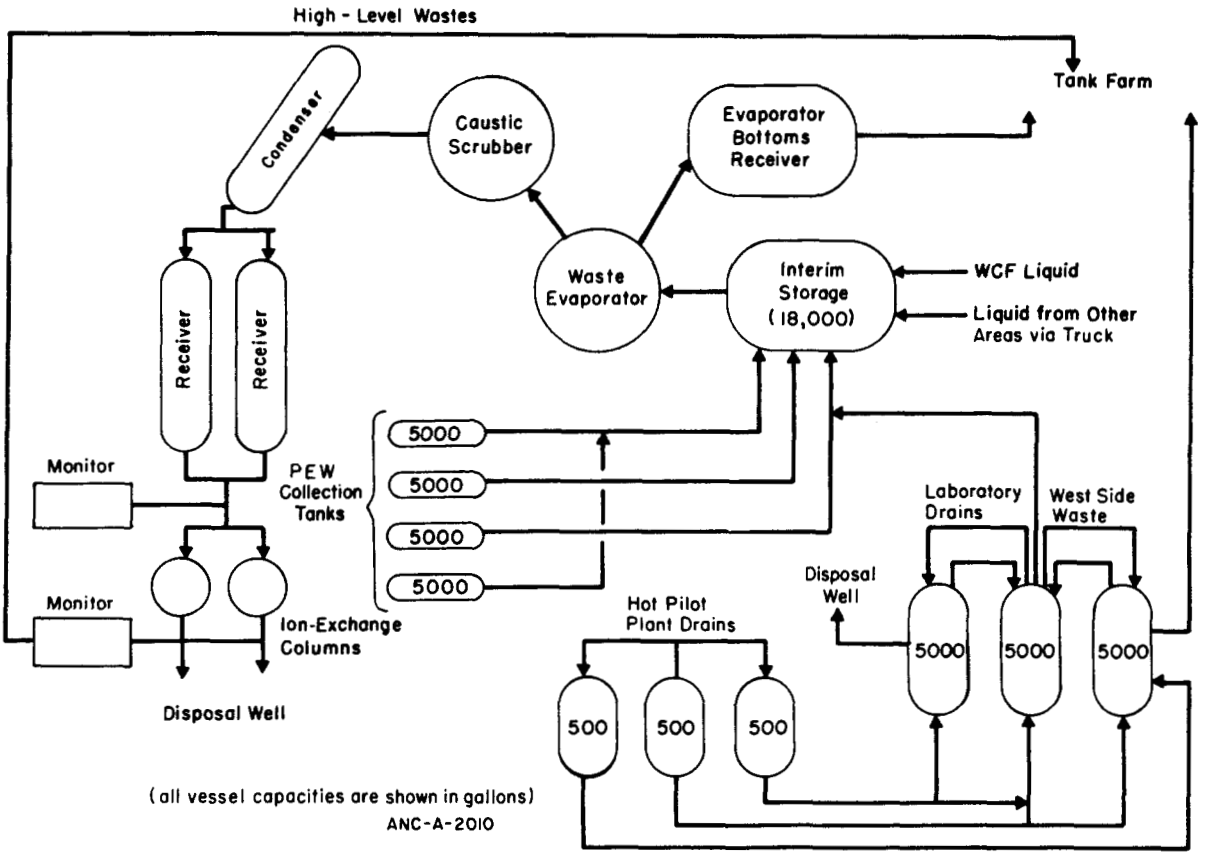


Figure II-27. Flowsheet of PEW System.

The headend process building has its own waste collection system. This system consists of three 500-gallon tanks located in vaults below the basement floor. These tanks, like the west side waste tanks, are for collection of cold, low-level, and intermediate-level radioactive liquid waste. The waste in each tank is transferred, when the tank is full, to the appropriate west side waste tank.

(7) Discharge Well

Liquid wastes from the PEW evaporator condensate and service waste systems flow to the ICPP discharge well after being monitored for radioactivity. The well is located south of the process building and is 598 ft deep, 10 in. in diameter, and penetrates 140 ft below the water table. The volume and associated activity of liquid wastes sent to the discharge well from 1953 through 1974 are shown in Table II-24. The average temperature of the discharged waste is approximately 70°F, whereas the average temperature of the aquifer is approximately 53°F.

TABLE II-24

ICPP LIQUID WASTE RELEASES TO DISCHARGE WELL

| Year | Volume ($10^8$ gal) | Total Activity (Ci) |
|---|---|---|
| 1953 | 3.4 | 16 |
| 1954 | 2.4 | 8 |
| 1955 | 4.0 | 15 |
| 1956 | 3.6 | 22 |
| 1957 | 2.3 | 285 |
| 1958 | 3.8 | 339 |
| 1959 | 3.4 | 47 |
| 1960 | 1.9 | 32 |
| 1961 | 1.9 | 625 |
| 1962 | 2.7 | 407 |
| 1963 | 2.6 | 1,117 |
| 1964 | 3.5 | 1,792 |
| 1965 | 4.2 | 116 |
| 1966 | 3.6 | 265 |
| 1967 | 3.0 | 870 |
| 1968 | 3.0 | 516 |
| 1969 | 3.3 | 163 |
| 1970 | 2.8 | 81 |
| 1971 | 2.8 | 62 |
| 1972 | 3.4 | 308 |
| 1973 | 3.4 | 34 |
| 1974 | 3.9 | 457 |

Two gamma scintillation detector systems (one specifically for cesium-137 and the other for all gamma energies) monitor a side stream of the waste going to the discharge well. A proportional sample also is collected daily and analyzed for gross beta. If the gross beta count is abnormally high, a strontium-90 analysis and a complete gamma spectrum analysis (i.e., identification of gamma emitting radionuclides) is performed. A proportional sample of service waste flow is added to a composite sample each day for analysis once each month. The monthly composite sample is analyzed for gross alpha, gross beta, gamma spectrum, transuranics, strontium-90, tritium, iodine-129, sodium, nitrate, chloride, sulfate. pH, dissolved solids, and conductivity[a].

The gamma scintillation detector systems are set to alarm at $6 \times 10^{-5}$ μCi/ml of cesium-137. Their detection limit is about $2 \times 10^{-6}$ μCi/ml. When both parallel detectors alarm, the waste is diverted automatically to a high-level waste tank by air activated valves. The alarms also sound in the Health Physics shift office to alert operating personnel that above-limit waste is being diverted. Process shutdown may then be required in order to determine why the service waste water is contaminated. To date, diversion has occurred only twice and both incidents were caused by a gradual buildup of activity on the radiation counters. Design modifications are being evaluated to eliminate this gradual buildup. A total of 15,000 gallons of waste have been diverted to high-level waste tanks in these two incidents.

The major radioactive constituent of the liquid waste discharge to the well is tritium. In 1974, out of a total activity of 458 Ci, tritium comprised 455 Ci; the remainder is a mixture of other fission products, activation products, and transuranics. Table II-25, shows the nuclides released to the disposal well during 1974.

d. Systems for Disposal of Nonradioactive Liquid Wastes

Cooling water, steam condensate, water softener, and demineralizer regenerative effluent, and drains in nonradioactive areas are classified as "service waste" and are discharged continuously to the aquifer via a discharge well. These waste streams normally contain no radioactivity.

A diversion system has been installed to divert the service waste to a storage tank in the event that radioactivity enters the system.

Wastes from the service building are primarily condensates from the heating and ventilating system, chemical wastes from boiler blowdown, and raw water demineralizer regenerant solutions. These wastes are discharged through a waste monitoring building directly to the discharge well since their source locations are nonradioactive areas. Table II-26 shows the source, volume, and chemical composition of service building waste before the waste is mixed with approximately $10^6$ gallons/day of condenser cooling water. These wastes are subsequently routed to the discharge well. Sanitary sewage wastes are handled in a separate system.

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[a] See response to Comment X.11.3, Section X for additional information on iodine-129.

TABLE II-25

LIQUID WASTE DISCHARGED TO WELL AT ICPP
DURING 1974

| Nuclide | $T_{1/2}$ | Ci |
|---|---|---|
| Antimony-125 | 2.7 yr | 0.03 |
| Carbon-14 | 5730 yr | 0.02 |
| Cerium-144 | 282 days | 0.025 |
| Cobalt-60 | 5.3 yr | 0.006 |
| Cesium-134 | 2.3 yr | 0.05 |
| Cesium-137 | 30 yr | 0.6 |
| Niobium-95 | 35 days | 0.003 |
| Plutonium-238 | 89 yr | 0.02 |
| Plutonium-239 | 24,360 yr | 0.004 |
| Ruthenium-106 | 368 days | 0.6 |
| Strontium-90 | 28 yr | 0.2 |
| Tritium | 12.5 yr | 455 |
| Unidentified beta-gamma | -- | 0.4 |
| Zirconium-95 | 65 days | 0.0003 |
| Total | | 457 |

TABLE II-26

WASTE SOLUTION FLOW RATES AND COMPOSITIONS
FOR ICPP SERVICE BUILDING WASTE

| | | Constituents (ppm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Waste Stream | Flow Rate (gal/day) | Calcium | Magnesium | Sodium | Potassium | Bicarbonate | Sulfate | Chlorine | Phosphate | Total | Approximate pH |
| Zeolite unit | 9,400 | 1,460 | 431 | 3,756 | — | — | — | 9,650 | — | 15,300 | 7.0 |
| Cation demineralizer | 2,000 | — | — | 3,601 | 129 | — | 15,608 | — | — | 19,300 | 0.8 |
| Mixed-bed unit | 1,100 | — | - | 1,941 | — | — | 3,610 | 52 | — | 5,600 | 12.0 |
| Boiler blowdown[a] | 3,300 | - | — | 728 | — | - | 810 | 282 | 217 | 2,000 | 7.0 |
| Combined wastes | 15,800 | 638 | 188 | 2,731 | 26 | - | 3,658 | 4,304 | 64 | 11,600 | [b] |

[a] Rounded off to nearest hundred.

[b] ICPP discharge well waste water pH based on samples during 1972 averaged 8.3.

Some chemicals occasionally are discharged in small quantities in the nonradioactive wastes from laboratories and pilot plants. These wastes mix with the service waste water; and the mixed waste then is discharged to the discharge well. The concentration of chemicals released to the discharge well is shown in Table II-27.

TABLE II-27

CHEMICAL CONCENTRATION IN SERVICE WASTE RESULTING FROM CHEMICAL USAGE AT ICPP

| Chemical Species | Concentration in Waste (ppm) | Drinking Water Standards[a] (ppm) |
|---|---|---|
| $Na^+$ | 52 | - |
| $Cl^-$ | 117 | 250 |
| $SO_4^=$ | 33 | - |
| Total | 202 | |

[a] USPHS Drinking Water Standards.

(1) Diversion System

The service waste diversion system[38] provides additional monitoring and automatic diversion of some of the service waste streams. Basically, the various service waste streams are monitored upstream from a diversion station. If no activity is detected, the normal flow is to the discharge well. If activity is detected, valves automatically divert the stream to a 300,000-gallon surface collection tank which was constructed for this purpose.

(2) Fuel Storage Building Service Waste

Owing to its distance from the main processing area at ICPP, the fuel storage building has its own service waste system for nonradiological waste. The heaters in the fuel storage building use high-pressure steam. The condensate was originally routed to the manhole west of the building for percolation through the earth materials. In 1972 this waste was rerouted and discharged underground into a dry well.

(3) Sanitary Wastes

Sanitary wastes generated at the ICPP are treated through five separate systems; four of these use septic tanks (WCF, fuel storage facility, guardhouse, and waste treatment building), and one uses an Imhoff process. The main sewage treatment plant (Imhoff process) serves

only three buildings. Sewage from these three facilities is collected in underground sanitary sewer lines which lead to the sewage treatment plant. This sewage flows into a manhole which serves as a receiving station for the raw plant effluent. Two sewage ejectors, with a total capacity of 60 gallons/min, transfer the raw effluent from the manhole to the Imhoff tank for chemical digestion. The digested sludge from the tank then flows to sludge drying beds; approximately 400 $ft^3$ of sludge remain in the tank at all times as "seed." Effluent from the Imhoff tank flows to a trickling filter where further digestion occurs; later all effluent liquids are chlorinated and released to an effluent disposal field. The original ICPP effluent varies from 25 to 80 ppm of five-day biological oxygen demand (BOD). Overall BOD reduction of 80% is attained by the system. All other sanitary wastes at various ICPP areas are disposed of and treated in septic tanks.

e. Systems for Disposal of Radioactive Solid Wastes

Two main types of radioactive solid wastes are generated at the ICPP:

(1) Calcined solids which are the solid granular products resulting from the solidifying high-level radioactive liquid wastes in the WCF

(2) Conventional radioactive solid waste such as contaminated rags, wood, mopheads, paper, plastic, and metal.

(1) Calcined Solid Waste[39][a]

Calcine produced in the WCF is transported pneumatically in doubly contained, shielded stainless steel lines to the storage facilities shown in Figure II-28. Production of calcine solids from liquid waste began in 1963 at the ICPP. From 1963 through 1974, $2.8 \times 10^6$ gallons of liquid waste have been converted to $4.3 \times 10^4$ $ft^3$ of solid calcine. The total activity at the time of calcination was approximately 53 million Ci. The inventory of the solid storage bins as of December 1974 is shown in Table II-28. The activity recorded in the table is less than the initial activity of 53 million Ci because of radioactive decay of the fission products contained in the bins. The principal long-lived isotopes present in the solids are cesium-137, strontium-90, cerium-144, and cesium-134. Typical physical, chemical, and radioactive properties of calcine solids are shown in Table II-29. Double containment of the solids is provided by means of storage in stainless steel bins enclosed in buried reinforced concrete vaults. The first and second sets of storage bins are full; the third is in the process of being filled.

The first storage facility consists of four units, each containing a central cylinder and two progressively larger concentric bins with annular spaces between bins for air cooling. The outer diameter of each unit is 12 ft. The original design does not provide for retrieval of the solids; however, retrieval may be accomplished by drilling holes

[a] See Appendix E, Section 3.B. for details on construction of additional calcine storage bins in 1976.

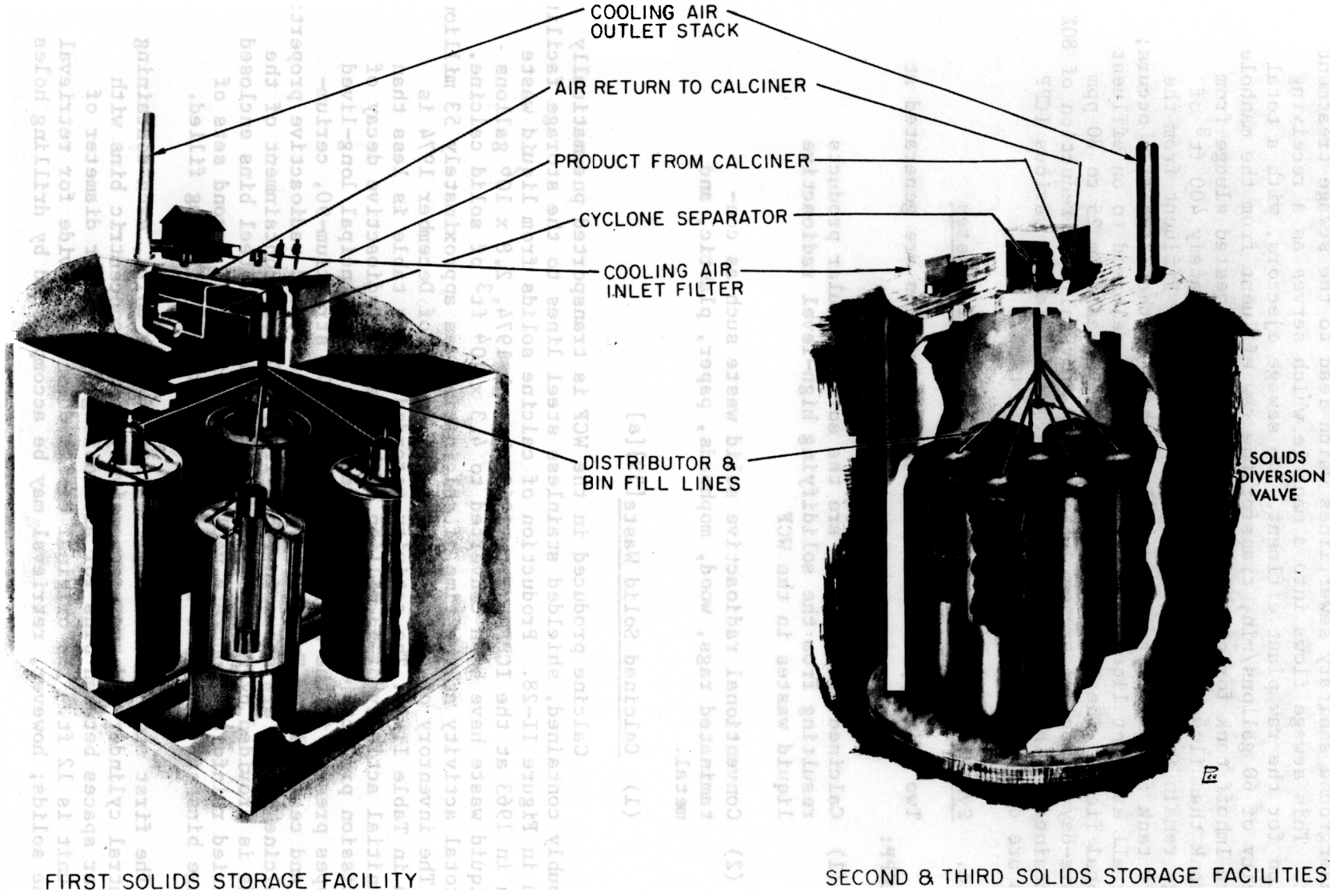


Figure II-28. Calcine Storage Facilities.

TABLE II-28

CALCINE SOLIDS INVENTORY AS OF DECEMBER 1974

| Storage Bins | Volume ($10^3$ ft$^3$) | Activity (Ci) |
|---|---|---|
| 1st set | 7.4 | $4.4 \times 10^6$ |
| 2nd set | 28 | $9.9 \times 10^6$ |
| 3rd set | 8.5 | $4.9 \times 10^6$ |

through the vault roof and the top of each bin, then inserting transfer equipment for solids retrieval. The four bins, with a total design capacity of approximately 7,800 ft$^3$, are surrounded by a rectangular reinforced concrete vault.

The second and third storage facilities consist of seven 12-ft-diameter cylindrical bins enclosed in a reinforced concrete vault. These two storage facilities differ primarily in the height of the bins. The second solids storage facility has a design capacity of 30,000 ft$^3$ of solids; the third facility is designed for 39,000 ft$^3$ of solids. The second and third facilities are equipped with retrieval ports to allow the retrieval and transfer of solids to another location.

The resistance of the bins and vaults to earthquakes has been studied. (See Section II.A.3.c.) The occurrence of an earthquake of magnitude near 7.75 (Richter scale) with an epicenter at the Arco scarp, about 20 miles west of the ICPP, would produce a maximum credible ground acceleration at the storage area of about 0.33 g (the design basis earthquake). This acceleration would not damage the concrete vault structure or the bins. The bin anchor bolts possibly might shear, and with anchor bolt failure some damage may be inflicted on bin vent piping above the bins. However, no major release of radioactive solids into the vault or to the environment will occur. If the ground acceleration is 0.18 g, the more probable value, calculations show that no damage to the bins, anchor bolts, or piping would occur.

Climatology and hydrology of the area preclude major flooding of the facility site in the current geological era. If, through some currently unidentifiable and extremely remote phenomenon, the storage area were to be totally flooded, the stainless steel bins have sufficient corrosion allowance to ensure that their integrity would be maintained for at least 500 years. After this time, the highly concentrated fission products would have decayed to stable nuclei and only oxides of transuranic nuclides and low-concentration fission products would be of concern. The rate of leaching of transuranics from calcined solids by water has been shown to be very low[39].

Meteorological conditions at the INEL will not result in bin or vault failure nor release of radioactivity to the environment. Wind

TABLE II-29

TYPICAL PROPERTIES OF CALCINER PRODUCT

| Physical properties: | Aluminum Waste | Zironcium Waste |
|---|---|---|
| Mass median partical diameter, mm | 0.56 to 0.70 | 0.6 to 0.8 |
| Bulk density, $g/cm^3$ | 1.0 to 1.2 | 1.7 |
| Composition (wt%): | | |
| Zirconium as $ZrO_2$ | -- | 21.4 |
| Calcium as $CaF_2$ | -- | 54.2 |
| Aluminum as $Al_2O_3$ | 88.2 to 89.1 | 21.9 |
| Sodium as $Na_2O$ | 1.3 to 2.0 | -- |
| Nitrogen as $N_2O_5$ | 3.9 to 4.1 | 1.9 |
| Mercury as HgO | 2.9 | -- |
| Water | 2.0 | 0.6 |
| Gross fission product oxides | 0.6 | -- |
| Radioactive properties: | | |
| Heat generation, Btu/hr-kg | 0.14 to 0.36 | 0.05 to 0.09 |
| Principal radioisotopes, Ci/kg | | |
| Strontium-90 | 2.23 to 3.3 | 0.36 to 1.14 |
| Cesium-134 | 0.09 to 0.18 | -- |
| Cesium-137 | 2.4 to 3.6 | 0.45 to 1.4 |
| Cerium-144 | 0.6 to 7.9 | -- |
| Ruthenium-106 | 0.02 to 0.23 | 0.004 to 0.01 |
| Zirconium-Niobium-95 | 0 to 0.23 | -- |
| Promethium-147 | 1.5 to 4.8 | -- |
| Plutonium-238 | ∿0.002 | ∿0.01 |
| Plutonium-239 | ∿0.0004 | ∿0.0001 |
| Plutonium-240 | ∿0.0001 | ∿0.00006 |

erosion of the alluvial soil in the vicinity of the facilities is slight, even at sustained wind velocities of 80 mph. A tornado, which normally contains the highest and most concentrated wind force known, would damage only structures on top of the concrete vault, but would have no effect on the integrity of the solid storage system.

During calcination, the bins are vented to the calciner vessel. During calciner shutdowns, the solids storage system valves are closed, and a separate vent system is placed in operation. This system consists of a water-cooled stainless steel mesh trap and demister, a condensate receiver with level detection equipment, and an absolute filter with differential pressure instrumentation. Gas is discharged directly to the ICPP stack. Since the bins were placed in service, no indication of liquid level or pressure drop buildup in the gas cleanup system has been observed.

Two methods of monitoring the storage vault for leaks were included in the storage facility design. Each vault contains a sump, sample lines, and jet with liquid-level instrumentation for detecting the entry of groundwater, rainwater, or floodwater into the vault. If liquid is detected, the jet can be used for transferring it to the ICPP liquid waste evaporator system. No liquid has been detected in the vaults since initial operation of the WCF. The second method for detecting leaks involves monitoring the cooling air passing through the vaults. Each outlet duct from the three sets of storage facilities contains an air sampling system which includes a HEPA filter for trapping particulate matter in the cooling air. If bin leakage were to occur, the radioactive particulates on the filter would activate a radiation monitor. The monitor then would close valves in the cooling air inlet ducts, thereby preventing discharge of radioactivity to the environment. Provisions have been included for installing HEPA filters in the outlet ducts so that flow of cooling air could be restored after their installation, if activity is detected.

Decay heat from the radioactive solids in the storage bins is removed by the combined processes of natural convection of cooling air through the bins, thermal radiation of heat to the vault walls, and conduction of heat into the surrounding soil. Fission product decay heating is monitored by means of thermocouples located in the calcine solids, on the bin and vault walls, in the cooling air space, and in the soil surrounding the vault. These thermocouples are located in a vertical row spaced 10 to 15 ft apart on the bin centerline, which is the hottest area. All temperatures are recorded weekly when filling a bin. After a bin is full, they are recorded monthly since the decay heat generation rate decreases with increasing age. The highest calcine temperature currently observed in any storage bin is 480°C. The highest bin wall temperatures are 50°C above the ambient air temperature. If cooling from atmospheric air were to be stopped, all cooling would be by natural convection and by conduction to the ground. This has been shown to give approximately 50°C higher centerline temperature in the bins, which is well below the design temperature.

(2) Conventional Radioactive Solid Waste

Conventional radioactive solid wastes may be divided into two main types which, in most cases, are distinctly different in radiological terms: routine and nonroutine.

Routine wastes vary in composition, depending on the facility or procedures involved in generating the wastes. Established INEL operating regulations define routine wastes as wastes which generate radiation fields of less than 500 mR/hr, 3 ft from the waste container packages. Restrictions in size and weight are imposed also. In addition, the regulations specify that no toxic, pyrophoric, or alpha emitting materials be present. Nonroutine wastes are solid wastes not fitting the description of routine wastes. Also included in nonroutine wastes are those containing transuranic materials.

Routine wastes consist of materials used in routine decontamination, maintenance, and operational activities such as contaminated rags, blotting paper, plastic wrap, gloves, shoe covers, wood, mopheads, glass, floor sweepings, scrap metal, and low-activity-level air filters. Routine wastes are collected in specially marked receptacles throughout the plant. The waste is then loaded in Dempster dumpsters and hauled by truck to the INEL Radioactive Waste Management Complex for disposal. Contaminated articles which are too large to fit inside the dumpsters are wrapped in plastic or enclosed in suitable containment and transported to the disposal area.

Another source of routine waste is the final filters from the WCF off-gas cleanup system. There are three filter units; each unit consists of a fiberglass prefilter in series with a HEPA filter. These filter units are located inside a stainless steel housing. Because of the high-intensity radiation fields, filter replacement is conducted remotely. In the past the filter units were transported by cask to the Test Area North (TAN) hot shop for filter removal, packaging, and shipment to the INEL Radioactive Waste Management Complex. The filter unit housings were then decontaminated and the new filters installed for future use. The filters are buried at the disposal area in the stainless steel housings in which they were used.

Transuranic wastes are nonroutine wastes produced in several areas within the ICPP, mainly the analytical laboratories. These wastes usually are in liquid form, and are absorbed in media, such as vermiculite or diatomaceous earth, at a centralized decontamination facility. The facility is designated as the transuranic contaminated waste receiving and storage area of the ICPP. A 20-year integrity, plastic lined drum (DOT Specification 17C or 17H) is located there for the purpose of storing solid wastes contaminated with transuranic nuclides. The decontamination technicians on duty receive the appropriately packaged (doubly contained) and identified wastes and deposit them in the drum. Filled drums are shipped to the Transuranic Storage Area located at the Radioactive Waste Management Complex.

The amount of waste generated varies with the types of operations during a particular month or year. During fuel processing shutdowns, the amount of radioactive waste increases because of the necessary decontamination procedures and of the radiation and contamination control procedures. The volumes of contaminated solid wastes, excluding calcine, generated yearly from 1961 through 1974 are shown in Table II-30. Table II-31 shows the nuclide summary in curies for 1974 of disposed and stored waste.

TABLE II-30

CONTAMINATED CONVENTIONAL SOLID WASTE
GENERATED AT THE ICPP

| Year | Volume ($10^3$ $ft^3$) | Radioactivity (Ci) |
|---|---|---|
| 1961 | 14 | 372 |
| 1962 | 7 | 102 |
| 1963 | 12 | 322 |
| 1964 | 19 | 254 |
| 1965 | 17 | 371 |
| 1966 | 27 | 18,780 |
| 1967 | 15 | 18,420 |
| 1968 | 18 | 19,800 |
| 1969 | 17 | 41,500 |
| 1970 | 22 | 188 |
| 1971 | 18 | 99 |
| 1972 | 19 | 37 |
| 1973 | 29 | 326,300 |
| 1974 | 34 | 4,303 |
| Totals | 269 | 430,800 |

f. Systems for Disposal of Nonradioactive Solid Wastes

Nonradioactive solid wastes are generated at nearly all buildings throughout the ICPP area. The composition of the wastes is nearly the same: (1) construction, office, and laboratory refuse, containers, and packaging materials and (2) garbage. Monthly estimates have been made over the last 4 years of the volumes of waste sent to the Central Facilites Area (CFA) sanitary landfill as shown in Figure II-29. Trash is collected from wastebaskets and other sources by custodians. The waste is surveyed for radioactivity by Health Physics personnel if it comes from areas of possible contamination. If radioactivity is not present, the waste is placed in specially marked dumpsters. The contents of the dumpsters are collected weekly, monitored, and taken to the CFA where they are buried and compacted in the sanitary landfill. Certain dumpsters are reserved and marked for disposal of scrap metal; this nonradioactive scrap metal is collected and either sold or buried.

TABLE II-31

NUCLIDE SUMMARY IN CURIES OF
SOLID WASTES ORIGINATING AT ICPP IN 1974

| Nuclide | Curies |
|---|---|
| **Disposed Waste** | |
| Antimony-125 | 107 |
| Cerium-144 | 784 |
| Cesium-134 | 43 |
| Cesium-137 | 1,136 |
| Cobalt-60 | 15 |
| Europium-154 | 42 |
| Europium-155 | 24 |
| Manganese-54 | 6 |
| Mixed Fission Products | 301 |
| Ruthenium-106 | 279 |
| Strontium-90 | 1,412 |
| Uranium-235 | <1 |
| Uranium-238 | <1 |
| Zirconium-Niobium-95 | 154 |
| Subtotal | 4,303 |
| **Stored Waste (TSA)** | |
| Neptunium-237 | <1 |
| Plutonium-239 | <1 |
| Plutonium-240 | <1 |
| Plutonium-241 | <1 |
| Ruthenium-106 | 1 |
| Subtotal | 1 |
| Total | 4,304 |

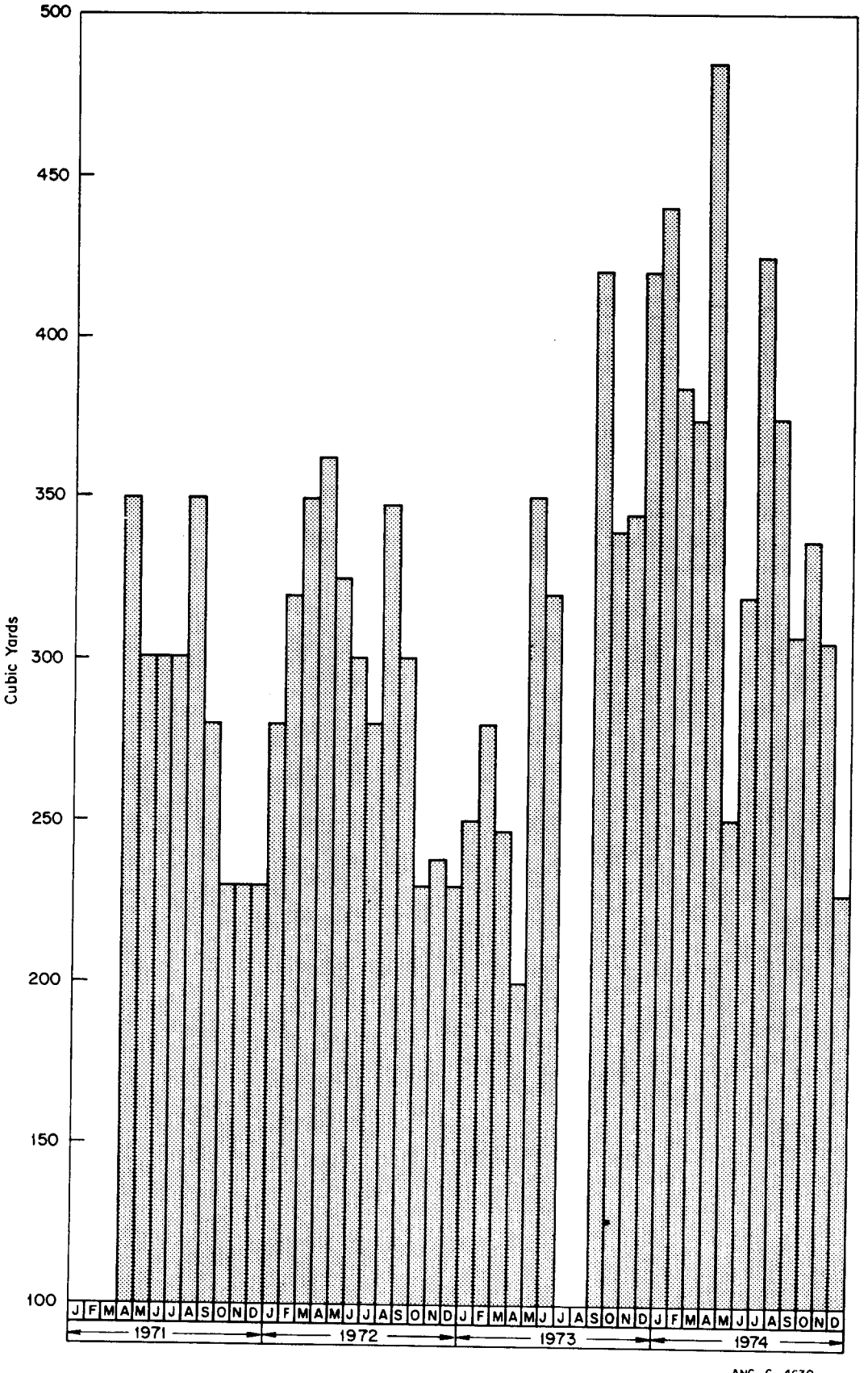


Figure II-29. Estimated ICPP Nonradioactive Solid Waste.

In the past it has been necessary to dispose of a variety of nonradioactive chemicals resulting from rather nonroutine operations. Among these have been nonradioactive calcined material (e.g., aluminum oxide) produced in preoperational testing of the WCF and nonradioactive waste resulting from preoperational checkouts and testing of fuel processing equipment. In most cases these nonradioactive materials were disposed of by burial.

Other nonradioactive chemicals have included liquid "NaK," a mixture of metallic sodium and metallic potassium. In this case the "NaK" was chemically reacted with water, and the resulting caustic solution was neutralized and disposed of by pumping out the solution onto the desert.

Still another material requiring disposal was a sizable quantity of kerosene contaminated with a nonradioactive organic material. This was simply added to boiler fuel and burned.

It should be noted that rather large quantities of nonradioactive chemicals used in water treatment are routinely disposed of via the ICPP disposal well.